Pit and Quarry

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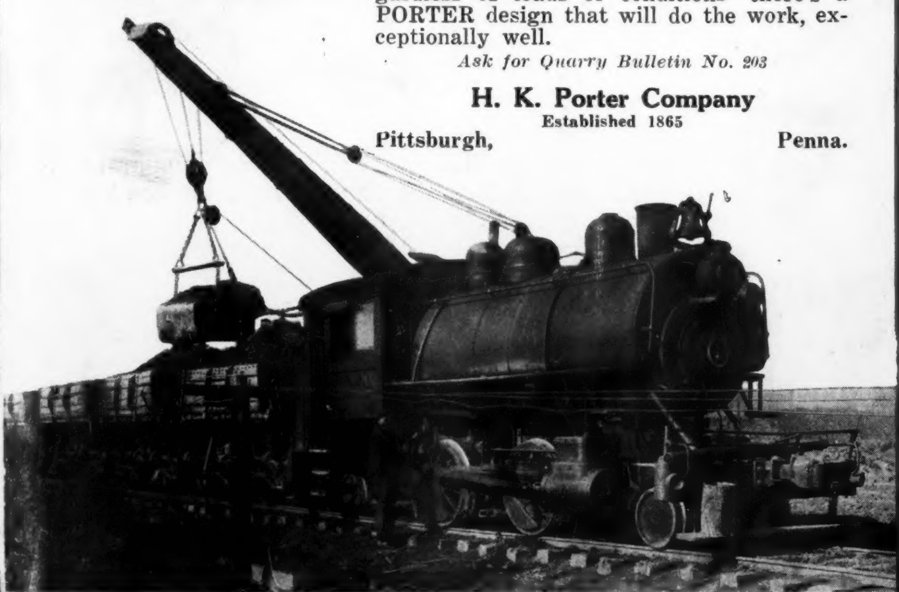

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Vol. 12 CHICAGO, APRIL 1, 1926 No. 1

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Pit and Quarry

Vol. 12 Chicago, Ill., April 1, 1926 No. 1

What They Say

SO MANY of those who have received the 1926 edition of the Pit and Quarry Handbook have written to the publishers enthusiastic letters of approval that its general acceptance as a reliable, authoritative reference book is established.

The vice president and general manager of a cement company in Seattle says, "it is one of the best reference books that has come to my attention." The manager of one of the largest crushed stone operations in Pennsylvania says, "exceedingly valuable information; not only to the engineer in the field, but to the plant superintendent and all who have to do with the purchasing and bettering of present methods." The president of a large feldspar company says, "we feel we must congratulate you on the increased improvement over previous issues, and the clarity of the various articles couched in such language as to be easily understood by the man who are not so fortunate as to be possessed of a highly technical knowledge, but still who are the men whom we must look to for efficiency, more necessary now than ever." The president of one of the largest sand and gravel operations in the state of New York says, "the most complete reference book of practical information regarding this industry that has ever come into our possession." The superintendent of one of the largest lime plants in the country says, "it is valuable to our plant for the information applying to limestone quarrying and lime plant production. We use it as a reliable reference." The superintendent of what is considered by many as the world's most modern cement plant says, "to be referred to as a standard of authority." Another cement official says, "complete as well as authentic—should interest everyone connected with the industry." A prominent engineer in the crushed stone and lime industry says, "very valuable to anyone connected with the industry." Another prominent engineer of the cement industry says, "authority for almost all questions . . . a most complete description of all problems encountered." The treasurer of a large crushed stone company says, "very valuable, compactly arranged, well indexed and a very valuable addition to the library of the crushed stone and sand and gravel industry." The owner of a large sand and gravel operation in Indiana says, "the most complete and useful article which we have ever received in our office."

From the hundreds of other letters we find expressions of significant approval. A few of these are, "unusually detailed and authoritative information," "the best edition ever published," "cannot afford to get along without it," "very complete in every particular," "have had several occasions to refer to it and in every case I have found the desired information," "a handbook in fact," "pertinent data and information are given in concise and understandable form," "the most complete handbook," "interesting and instructive," "up-to-the-minute," "a useful text especially for quarry and plant superintendents," "filled from cover to cover with very practical information," "thankful to receive it," etc., etc.

If you or your company have received a copy of the 1926 Handbook and have not acknowledged receipt, please send us your acknowledgement on the green card provided for the purpose and inserted under the front cover of your copy. If the card has been lost, a letter merely stating that a copy was received and who in your organization will retain it will be appreciated.

Who Will Carry the Loss?

RAILROAD legislation is generally of interest to the country as a whole. The defeat of the Gooding bill in the Senate on March 24th is of special interest to producers, as the defeat of this bill prevents the Senate from interfering with the rate making powers of the Interstate Commerce Commission. The Gooding bill was the most important railroad measure which has been up in the Senate for some time, and it was intended to prohibit the Interstate Commerce Commission from ever allowing the railroads to carry midwestern products to the Pacific Coast at a low rate in order to meet Panama Canal competition. In spite of the decisive defeat of his bill Senator Gooding declares he will fight on. Well, if he does not do so, someone else probably will, because of the conditions which will continue and will possibly grow worse.

The great growth of the waterborne commerce between the Atlantic and Pacific sections of this country through the Panama Canal has exceeded the most optimistic beliefs of its advocates. It has evidently benefited some sections and deprived others of advantages which they previously enjoyed. The transcontinental railroads' plea that they should be authorized by the Interstate Commerce Commission to name rates to meet the competition of the water lines at terminal points, regardless of the long and short haul clause, may possibly start new problems in transportation. The steamship lines now operating between Atlantic and Pacific Coast ports, and the volume of the freight they carry east and west, introduced a problem which the railroads insisted could be solved only by granting authority to the railroads interested to establish a lower rate to Pacific Coast ports served by the steamship lines as compared to the rates prevailing to points intervening where the distance is shorter. Of course, since the Gooding bill has been defeated, the steamship lines may make, if they choose, lower rates for longer hauls or favor one port.

Such action would probably introduce new problems for the transcontinental railroads. Some railroads might benefit and others suffer, and so some sections might be injured or benefited, as is claimed now. Possibly intercoastal steamship lines should be placed under the control of the Interstate Commerce Commission in the same manner and to the same extent as the interstate railroads are now placed under that control. Personally, we favor such a plan. At the present time the intercoastal shipping business is very unstable. The service is not uniform. Some comcompanies use their vessels in this service only when it is highly profitable. Those companies which maintain a continuous service are frequently placed at a disadvantage due to price cutting and seasonal variations in business. It seems to be generally understood, however, that freight can be moved at a lower rate by water, and still leave a good margin for profit, than it can be moved by railroads without an appreciable loss. Our inquiry is: Who will carry the loss?

The Panama Canal has stimulated a vast increase in traffic, and it will undoubtedly continue to do so. The problem will develop into one of great seriousness. The defeat of the Gooding bill may develop a competition between the transcontinental railroads and the intercoastal steamship lines, which would prove disastrous to many. These steamship lines can cut rates below what the railroads could stand. Are the railroads in meeting this competition going to offer rates which will necessitate an increase on short haul traffic to carry the loss? The defeat of the Gooding bill has prevented Congress from interfering with the Interstate Commerce Commission in fixing rates. For this reason the defeat is most welcome. However, there are possible developments which may be serious to producers in the non-metallic mineral field. In practically every instance the freight rate on non-metallic mineral products is too far out of line now, and further increases may create such conditions of unfair competition that sales for many will be restricted to a much smaller territory. If the non-metallic mineral industries will have to carry any part of the loss which results from the establishment of rates by the railroads in order to compete with steamship traffic, there is sure to be at least a temporary check in their progress.

Notes on Aluminate Cement*

By G. Agde and R. Klem

IN Germany there has hitherto been no great amount of "Ciment fondu" manufactured as there has been in France. Among others the reason for this is the scarcity of suitable German bauxites which would be the chief raw material. Germany has workable deposits only in the Vogelsberg, but the lack of uniformity and the low grade of the ore as compared to foreign bauxites have left the unproved statement unchallenged.

In studying the literature on "ciment fondu" it was found that in contradistinction to portland cement there is still a series of questions to be answered of importance for an understanding of and a judgment respecting "ciment fondu." The fact that these are still open questions is astonishing because the literature shows that "ciment fondu" is not so new as is generally assumed. On the contrary, during the investigation of portland cement numerous preliminary studies on "ciment fondu" or aluminate cements, as they are also called, were carried out.

It appears that the study of the aluminate cements is as old as portland cement, that at the beginning of the production of hydraulic cements on a large scale these combinations were studied. However, they were chiefly qualitative combinations leading to variable results. The cause of this variation is probably to be found in the technical imperfection of the working methods at the time; only in recent times when it became possible to prepare the compounds and mixtures in question at higher temperatures did the results become uniform.

Fremy (C.r.vol.60 p.993, year 1865) first and then Michaelis (Hydr.Mortel, Leipzig 1869, p.35) prepared true fused compounds of known composition in which both found remarkable hardening properties and high strength values. The best compositions given by both are the same so that these figures were determined for products which could be used practically.

Several other investigations in the field of high lime aluminates (Wagners Jahresber. 1867, vol.13, p.410; T.I.Z. 1882, p.177; Ann.d. Mines 1887, II, page 345; Gazz. Chim. 1889) led to no results.

The works to this time had considered only the qualitative investigation of the hardening power and the determination of the ratio of the components. The first to test the strength quantitatively whilst determining the composition exactly was O. Schott (Dissert. Heidelberg 1906). This frequently quoted work is the precursor of a series of similar investigations which, however, always dealt with the aluminates with the purpose of investigation and development of portland cements. Killig (Protokolle 1913, p.408) and Endel (Prot. 1919) in their work define the limits within which useful products may be produced. The well known works of Shepherd, Rankin, and Wright (Z. anorg. ch. 1911, vol.71, p.19), Jaenecke and R. Gruen (Zement, 1923, p.3) give a complete review of the relationship existing in the ternary diagram for $CaO-Al_2O_3-SiO_2$. In the last named the results are supplemented by microscopic preparations.

These works approach the goal which Fremy and Michaelis had already indicated, namely, the use of such aluminates as a structural material. Even if more recently the American Spackmann (Proc.f.Test. Mat.1910, p.10; German patent 234367 Class 80b of 1908) and the Frenchman Bied claim the honor of inventing aluminate cements, nevertheless the knowledge of these cements is considerably older; the great bauxite deposits of Southern France have made it possible to produce the first aluminate cements there technically even during the war. But the process itself is not commonly known (T.I.Z. 1923, p.325; Beton and Eisen, 1922, p.275, 1923, p.271). From the scanty publications it appears that these cements are melted either in water-jacketed cupola furnaces or in electric blast-furnaces and the procedure is similar to blast furnace procedure.

As the various short reports and contributions (Zement 1923, p.49, 142, 1924, p.67; Bauing, 1923, p.2; T.I.Z.

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*Report from the Technical and Electrochemical Institute of Darmstadt Technical High School, (Zeitschrift fuer Angewandte Chemie, 1926, No. 6). Translated by Albert P. Sachs, Technical Director, Universal Trade Press Syndicate, exclusively for Pit and Quarry.

TABLE Ia

Analysis: Percentage by Weight

Run No.			SiO_2	FeO	CaO	Fe_2O_3	Al_2O_3	Sum	Water Required in %: H_2O	1/2n $NaOH$	1/50m Sugar
1	K_1	Ia, Ib	20.35	1.96	30.95	5.97	41.29	100.52	30	—	—
2		IIa	10.81	3.65	47.32	18.78	19.92	100.48	25	32	—
3		IIb	10.04	1.61	47.87	19.79	20.11	100.42	25	28	—
4	K_2	Ia	20.74	1.50	30.15	11.21	36.95	100.55	31	29	29
5		Ib	20.89	1.96	27.22	5.50	43.90	99.47	30	29	29
6		IIa	10.52	3.66	38.91	20.52	27.26	100.81	31	28	—
7		IIb	10.91	1.95	41.00	24.28	22.44	100.53	30	28	—
8	K_3	Ia	18.61	0.88	28.13	12.24	40.20	100.06	30	30	28
9		Ib	19.80	1.20	31.24	7.40	41.24	100.88	30	30	29
10		IIa	12.62	0.82	42.75	27.09	16.15	99.43	30	28	—
11		IIb	18.50	3.67	41.12	22.31	14.62	100.22	30	28	—
12	K_4	Ia	21.50	1.01	25.36	4.04	48.47	100.38	32	31	29
13		Ib	15.02	0.91	28.41	7.52	48.06	99.92	36	35	32
14		IIa	15.06	2.41	20.80	28.10	34.71	101.08	27	28	—
15		IIb	12.92	0.89	20.91	28.77	36.76	100.45	25	27	—
16	K_5	Ia	19.20	0.92	45.53	10.79	23.02	99.46	28	—	—
17		Ib	18.75	1.06	44.14	8.50	28.28	100.73	35	—	—
18		IIa	11.23	1.23	60.02	17.05	10.58	100.11	45	—	25
19		IIb	12.74	0.98	61.44	15.86	7.88	98.90	45	—	28
20	K_6	Ia	27.62	0.57	31.45	12.73	28.27	100.64	31	29	28
21		Ib	28.15	0.84	34.93	10.07	25.14	99.13	31	29	29
22		IIa	27.49	0.77	35.29	15.96	20.88	100.39	30	29	—
23		IIb	27.05	1.02	34.05	17.31	21.08	100.51	29	29	—
24	K_7	Ia	22.15	0.84	40.42	7.86	29.41	100.73	30	31	28
25		Ib	21.78	1.24	42.18	5.64	29.53	100.37	28	28	28
26		IIa	18.23	0.72	46.61	16.09	19.01	100.66	27	31	—
27		IIb	18.13	1.08	52.97	16.93	11.24	100.35	28	28	—
28	K_8	Ia	19.91	0.84	41.02	13.28	25.59	100.64	31	30	28
29		Ib	19.83	0.31	35.56	7.70	37.05	100.55	29	30	28
30		IIa	18.25	0.90	40.32	19.13	21.54	100.14	28	29	—
31		IIb	17.62	0.73	41.20	18.20	22.45	100.20	30	29	—
32	K_9	Ia	15.04	0.32	46.02	3.98	34.85	100.21	30	33	—
33		Ib	14.18	0.48	44.33	5.67	35.72	100.38	32	30	—
34		IIa	13.74	0.41	49.32	17.65	18.91	99.99	38	32	—
35		IIb	13.58	0.66	52.88	15.63	17.77	100.52	38	35	—
36	KR	I	22.85	——	54.45	——	24,58	100.88	65	63	43
37		II	22.54	0.47	54.49	4.12	18.90	100.52	55	56	38
38		III	18.24	0.80	50.74	17.65	13.23	100.66	56	57	43
9		IV	18.88	0.70	46.83	27.17	6.71	100.29	46	46	—
0		V	17.62	1.20	44.47	32.02	4.38	99.69	45	50	—
1		VI	18.24	0.97	43.39	38.04	——	100.54	46	48	—

TABLE Ib

Melts According to K. Endell
Percentages by Weight

	1	2	3	4	5	6	7	8
iO_2	11.4	6.5	16.4	11.4	20.3	8.3	7.1	11.3
l_2O_3	41.5	54.7	34.8	55.0	29.1	64.0	47.0	48.7
e_2O_3	0.6	1.3	0.5	0.7	0.7	0.6	1.8	1.4
aO	46.1	37.1	48.4	32.6	50.2	27.0	44.2	39.4
gO	0.6	0.6	0.6	0.5	0.2	0.2	0.3	0.4
O_3	trace	0.1	trace	0.1	...	...	0.1	...
	...	0.3	0.1	0.2	...	0.1	...	0.1
olatile	...	....	0.8	0.2	0.1	...	0.2	...
	100.2	100.6	100.7	100.4	100.6	100.2	100.7	101.3

TABLE Ic

Technical Fused Cements
Percentages by Weight

	I	II	III	IV	V
SiO_2	9.65	11.34	10.00	5.00	10.25
l_2O_3	43.30	38,17	37.80	39.00	43.81 (Al₂O₃ + Fe₂O₃ bracketed)
e_2O_3	5.35	6.31	0.20	15.10	
FeO	....	....	5.50	1.00	....
Fe	....	....	....	2.60	0.56
CaO	48.82	42.45	42.40	34.80	40.30
MgO	0.66	0.36	0.30	0.20	0.31
SO_3	0.28	0.05	0.70	0.10	0.06
S	....	0.25	0.60	trace	0.07
TiO_2	....	....	1.70	2.20	....
Insoluble	....	1.12	trace	0.20	1.47
Volatile	....	....	0.30	....	0.15
	108.06	100.04	99.50	100.20	96.98

I=N. de Tédesco, Beton u. Eisen 1922, p. 275.
II=Müller (Kalkberge) as above, both ciment fondu.
III=Troche-Christiani, Beton u. Eisen 1923. Swedish product.
IV=Hummel, Bauingenieur, 1924, p. 110, ciment electric.
V=G. Nietzsche, Zement, 1923, p. 142, ciment fondu.

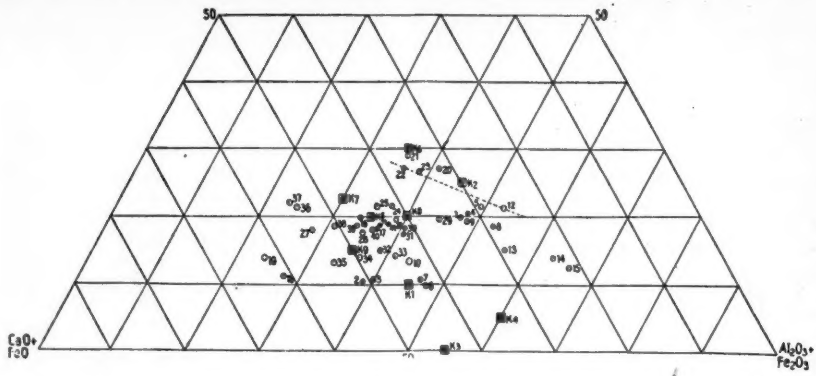


Diagram 1
Weight Percentages of the Original Melts Made in This Investigation (Table Ia)

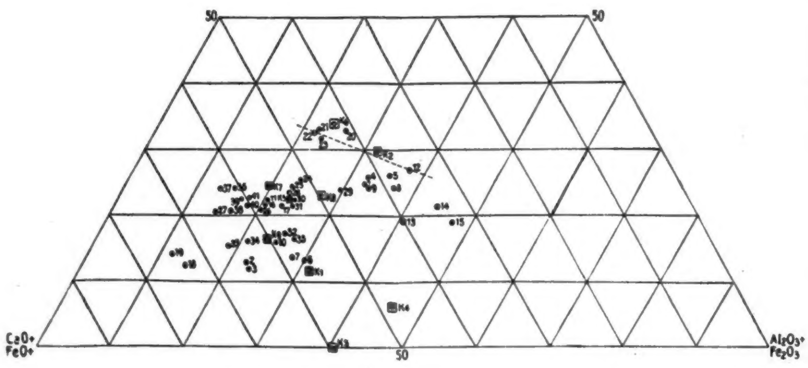


Diagram 2
Molecular Percentages of the Melts in This Investigation (Table IIa)

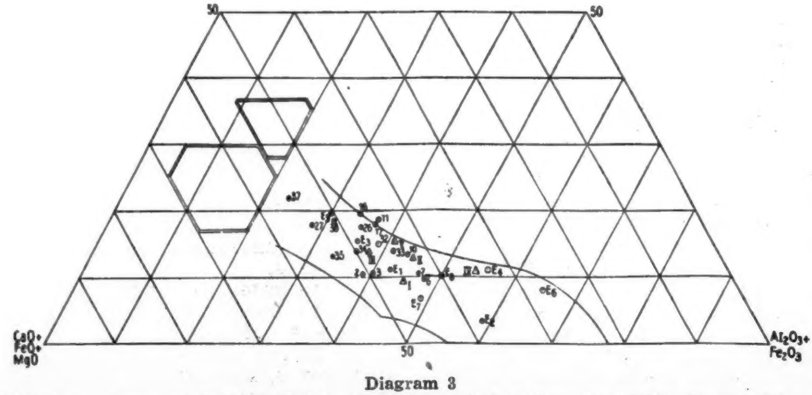


Diagram 3
Weight Percentages of Endell's Melts and of the Technical Cements (Tables Ib and Ic). At the Left the Fields of Portland Cement and Foundry Slags

1923, p.325, 1924, p.249, etc.) deal chiefly with the technical and physical constants, we shall first determine whether the German Vogelsberg bauxites are suited for the manufacturing process.

Besides determining the suitability of Vogelsberg bauxite we shall attempt to solve the following problems:

1. To determine the limits for technical aluminate cements in the ternary diagram so as to complete Endell's work;
2. To determine the chemical and crystallographic structure;
3. To determine the relationship to portland cement, and,
4. To clarify the phenomena on hardening and binding of these cements.

Method of Operation

As distinguished from most of the usual methods of investigation technical methods will be used as far as is possible. Crucible furnaces had to be avoided, as in practice cupola furnaces or electric furnaces similar to electric blast furnaces are used. The simplest solution was to produce fusion by direct arc heating; on the basis of preliminary tests it was adopted exclusively.

The furnace used consisted of two pot shaped hollowed-out Dynamidon pipe stones which could be set one above the other. Lateral openings in the lower "pot-stone" served for electrode leads (carbon electrodes). An opening in the top of the upper stone in which a funnel was inserted permitted observing the course of the reaction and permitted charging the furnace during operations. Later cover stones were used, into the 4 inch thickness of which the funnel was built. The furnace took a charge of 200 grams (nearly ½ lb.) and was operated by a current of 140 volts and 70-120 amperes.

The melting was so conducted that after a part of the charge was fused by the radiant heat the electrodes were adjusted close to the surface. The arc then struck against the melt similarly to the Héroult electric steel furnace, and the charges were quickly and thoroughly fused.

The Dynamidon material has the great advantage on the one hand of consisting of the same raw material as a large part of the charge, and on the other hand together with high refractory value it was resistant to wear so that only small quantities of impurities entered the charge, a great advantage of melting without crucibles.

The melts were prepared from mixtures which were made up on the basis of the following analyses of raw materials.

Bauxite		Lime	
Al_2O_3	32.40%	CaO	50.30%
Fe_2O_3	31.51%	CO_2	41.84%
SiO_2	12.34%	SiO_2	2.60%
TiO_2	4.26%	Al_2O_3	1.05%
CaO	0.52%	Fe_2O_3	0.09%
H_2O	18.98%	CaO	0.47%
		MgO	0.29%
	100.01%	Graphite	0.30%
			100.00%

The mixtures were calculated according to the data of Endell, Killig, Gruen, etc., and according to the analyses of technical aluminate cements which are reported in various articles and are summarized in Table Ic. We started with an Al_2O_3:CaO ratio of 45:45% of the weight of the mixture. Then the quantity of CaO was diminished in proportion to Al_2O_3 until with K_4 a maximum of 60% Al_2O_3 was reached. K_5 lies at the other extreme with 45% CaO:35% Al_2O_3. The other mixtures lie within this region—

K_1	45%	CaO	:	45%	Al_2O_3
K_2	30%	"	:	45%	"
K_3	45%	"	:	55%	"
K_4	35%	"	:	60%	"
K_5	45%	"	:	35%	"
K_6	35%	"	:	35%	"
K_7	47.5%	"	:	30%	"
K_8	40%	"	:	40%	"
K_9	50%	"	:	35%	"

As other influences were to be studied simultaneously, namely, the influence of chilling and the effect of iron oxide, half of each mixture was allowed to cool slowly and the other half chilled as rapidly as possible.

In order to investigate the influence of the Fe_2O_3 content five times as much carbon was added to the charge as was theoretically necessary for complete reduction, as strong oxidation was to be expected. In this way there were four series of melts, four products for each composition of charge.

1. The reduced slowly cooled melts,
2. the reduced chilled melts,
3. the unreduced slowly cooled melts,
4. the unreduced chilled melts.

In the unreduced melts the iron oxide was calculated as an acid and added to the alumina. For the sake of better mixing all the components were finely ground and then agglomerated with a very little water and the lumps formed were dried over night.

The charge was then melted down in the manner described, care being taken that the electrodes did not touch the charge as this would have produced electrolysis.

The melts were generally quite fluid so that the reduced iron could unite to form a regulus. Only in a very few viscous charges did the iron remain in suspension.

During the fusion there was a vigorous evolution of gas, especially in the reduced melts in which CO escaped from the furnace producing a long flame.

The slowly cooled charges solidified in large lumps which could easily be removed from the furnace as the outer layer of charge did not melt and thus prevented baking onto the walls.

The chilling had to be carried out chiefly in the furnace which involved brutal treatment of the furnace stones, but they held out quite well as approximately 20 melts could be made in one pot. All the charges melted between 1400° and 1600° C. After freezing, the adhering unfused material was brushed off with a steel brush and the lumps were crushed. In the reduced melts the larger pieces of iron were picked out and then the whole was crushed in a steel mortar and then finally pulverized in a small ball mill.

After the grinding the material was sieved through a screen with 4900 meshes per s. cm. (about 175 mesh); most of the iron remained on the screen and the rest wash removed from the flour by a horse-shoe magnet.

The flours, similarly to the melts, were of a gray-brown color, the reduced charges were light blue to gray blue.

Investigation of the Cements

(a) The Chemical Composition

SiO_2, FeO, CaO, Fe_2O_3 and Al_2O_3 were determined in the cements. The totals were always approximately 100% as Table Ia shows, so that all the components were found.

FeO was determined in a separate solution by titration with 1/10n $KMnO_4$.

The weight percentages of the analyses are given in Table Ia and in diagrams 1 and 3. It appears in considering the diagrams that the analyzed products differ appreciably from the mixtures made, especially in the cements with a high content of sesquioxides.

This difference might be due to two causes depending on the type of fusion. In the reduced melts the cause is due doubtlessly to the fact that Fe_2O_3 is only partially, and not, as intended, completely, reduced to metallic iron. Naturally a higher content of sesquioxides is present than was calculated. On the other hand by the loss of iron oxide there is a relative increase in the silica content.

In the unreduced melts the change is also produced by the iron oxide, but this time in a negative sense; for at high temperatures part of the iron oxide sublimes and precipitates on the furnace walls. This loss, which, depending on the duration of fusion, may reach a third of the total iron oxide, produces naturally a relative increase in the silica content.

However, this relative increase in silica, as the table shows, is especially large for the reduced charges; in the charges rich in lime, the influence of this change is not so great, as the proportion of bauxite in the charge is not so large. In the reduced charges it was to be expected that calcium carbide would form in considerable quantities. Similarly the formation of aluminum carbide was to be expected. This was not confirmed; carbides could not be detected analytically in the melts, only on the electrodes now and then a coating of yellow aluminum carbide was to be seen.

(b) The Technical and Physical Tests

K. Endell (Zement 1919, p. 334, Prot. 1919) gave, on the basis of his tests the probable limits within which the melts assumed the character of fused cements (Table Ib).

First the specific gravity of all the melts was determined (Table IIa). It lies approximately between 3 and 3.5. It was determined in a pyknometer with water, a method which is excellent, even with quick hardening cement.

The first test was the setting test. 10 grams were first stirred up with water which was added from a burette. The water requirement was thus simultaneously determined (Table Ia). It amounted on the average to 25-30 per cent. Several, however, exceeded this figure considerably. All of these were especially quick setting.

From this it appeared that of all the melts only K_3 Ia and Ib, K_2 Ia-IIb and best KR II and III entered into consideration.

Table IIa
Analysis of the Melts in Molecular Percentages
(Molecular percentages = percentages of SiO_2, R_2O_3, R'O, etc., based on the sum of all the molecular weights of the components.)

Run No.		SiO_2	FeO	CaO	Fe_2O_3	Al_2O_3	Molecular Ratio SiO_2	Molecular Ratio CaO	Molecular Ratio Al_2O_3	Specific Gravity
1	K_1 Ia, Ib	24.854	2.008	40.657	2.719	29.769	5	8	6	......
2	IIa	12.932	3.668	60.934	8.395	14.073	2	10	3	3.3819
3	IIb	12.014	1.640	63.227	8.872	14.236	4	21	7	3.3950
4	K_2Ia	15.538	1.538	40.291	5.249	27.126	3	5	4	3.6879
5	Ib	26.156	2.055	36.686	2.578	32.530	9	12	11	3.2432
6	IIa	13.264	3.864	52.843	9.663	20.369	1	4	2	3.4752
7	IIb	13.849	2.068	55.893	11.493	16.794	1	4	2	3.3889
8	K_3Ia	24.261	0.945	37.945	5.958	30.891	2	3	3	3.3057
9	Ib	24.295	1.236	41.223	3.390	29.851	3	5	4	3.1074
10	IIa	16.024	0.872	58.201	12.871	12.098	2	7	3	3.4017
11	IIb	22.410	3.716	53.394	10.094	10.431	4	10	3	3.3108
12	K_4Ia	26.957	1.063	34.213	1.887	35.879	3	4	4	3.4648
13	Ib	19.396	0.983	39.412	3.625	36.584	6	13	13	3.8973
14	IIa	21.386	2.873	31.765	14.896	29.082	2	3	4	3.5269
15	IIb	18.893	1.091	32.782	15.661	31.626	6	11	14	3.5310
16	K_5Ia	21.175	0.890	56.580	4.658	15.698	5	14	5	3.2896
17	Ib	21.554	1.023	54.590	3.647	19.187	7	18	7	3.1704
18	IIa	12.592	1.162	72.150	7.119	6.979	1	6	1	3.3872
19	IIb	14.133	0.911	73.246	6.564	5.152	1	6	1	3.3302
20	K_6Ia	33.152	0.577	40.564	5.704	20.003	4	5	3	3.1772
21	Ib	33.110	0.829	44.188	4.418	17.454	3	4	2	3.0576
22	IIa	32.566	0.777	45.103	7.066	14.487	3	4	2	3.1665
23	IIb	31.121	1.035	44.220	7.803	15.020	3	4	2	3.1851
24	K_7Ia	25.543	0.863	50.171	3.387	20.034	1	2	1	3.1817
25	Ib	24.833	1.184	51.714	3.024	19.867	1	2	1	3.3608
26	IIa	21.135	0.701	58.115	7.045	13.004	1	3	1	3.3193
27	IIb	20.364	1.018	63.987	7.181	7.449	3	9	2	3.5150
28	K_8Ia	23.296	0.836	52.835	5.923	17.846	4	9	4	3.2810
29	Ib	23.866	0.307	46.029	3.492	26.304	4	8	5	3.1550
30	IIa	22.660	0.921	52.725	8.768	15.442	4	9	4	3.3424
31	IIb	21.375	0.741	53.568	8.300	16.018	2	5	2	3.3552
32	K_9Ia	17.261	0.309	57.018	1.726	23.685	2	7	3	3.1219
33	Ib	16.557	0.467	55.801	2.509	24.666	2	7	3	3.1892
34	IIa	16.132	0.408	62.684	7.848	13.129	2	9	3	3.3372
35	IIb	15.544	9.634	65.077	6.755	11.995	2	9	3	3.3460
36	KR I	24.065	.....	60.546	.....	15.247	5	12	3	2.9956
37	II	23.918	0.419	62.183	1.651	11.833	2	5	1	2.9962
38	III	20.763	0.769	62.017	7.584	8.892	3	9	2	3.1240
39	IV	22.453	0.689	59.929	12.211	4.714	5	15	4	3.3665
40	V	21.743	1.231	58.884	14.975	3.167	5	15	4	3.4736
41	VI	22.743	1.017	58.300	17.940	.....	3	7	2	3.6265

If in the case of products from K_1 to K_4 we take several per cent less than the water requirement, they behave like very rapid setting cements. If they are stirred smoothly and the water requirement is determined they show no setting power. They could be considered as "flooded." In general a noticeable excess of water always seems to exercise an injurious effect, an observation confirmed by the behavior of the other melts. Also K_6 Ia-IIb, K_7 Ia and Ib, K_8 Ia-IIb showed the same behavior as those mentioned above. These are the ground products the analytical points for which lie outside of bounds toward the Al_2O_3 field.

The melts within the limits K_8 Ia and Ib, K_9 Ia-IIb show a water requirement of 28-38 per cent, values equal to those given by Endel for his products.

Table IIb
Melts According to Endel Molecular Percentages

	1	2	3	4	5	6	7	8
SiO_2	13.166	8.100	18.208	14.263	22.060	10.975	8.509	13.527
Al_2O_3	28.279	40.313	22.796	40.603	18.616	49.933	33.213	34.398
Fe_2O_3	0.262	0.599	0.210	0.331	0.287	0.300	0.814	0.633
CaO	57.259	49.836	57.790	43.867	58.670	38.396	56.931	50.725
MgO	1.036	1.121	0.996	0.936	0.325	0.395	0.537	0.716
	100.002	99,969	100.000	100.000	99,958	99,999	99,999	99,999

The products which lie on the one side towards the portland cement region and on the other towards the CaO region show a water requirement which is abnormally high, namely, 45 to 65 per cent. These are the products which set exceptionally fast and never give satisfactory strength tests.

Table IIc Technical Melts Molecular Percentages

	I	II	III	IV
SiO_2	10.664	13.756	12.020	6.763
Al_2O_3	28.233	27.320	26.810	31.128
Fe_2O_3	2.233	2.891	0.091	7.713
FeO	....	......	4.187	1.135
MgO	1.091	0.653	0.539	0.405
CaO	57.781	55.380	54.815	50.620
TiO_2	....	......	1.539	2.240
	100,002	100,000	100.001	99.999

These irregular products as well as those which though supposedly in the cement region showed no setting power were treated with various solutions which are considered to influence the phenomena of setting.

First ½ n caustic soda was used. It was found that those melts which in spite of their position within the bounds did not set, gave satisfactory strength tests with ½ n caustic soda. A similar but smaller increase in strength was produced by a 2 per cent solution of calcium chloride.

As these results were very satisfactory the same tests were made with products lying outside of the limits. In this case the absorption (Table Ia) remained about the same, but the results were the same as with water, that is to say, no hardening. KR I-VI were also investigated for setting properties. The results will be correlated later. One thing may be said beforehand: the first members of these series are excessively rapid setting.

Table IIIa Table of Moduli

	Hydr. Mod.	Alum. Mod.	Setting Mod.	Molecular Ratio SiO_2:CaO:Al_2O_3
K_5Ia	0.876	2.134	2.435	5:14: 5
K_5Ib	0.814	3.327	4.087	7:18: 7
K_9Ia	0.860	8.756	10.179	2: 7: 3
K_9Ib	0.806	6.300	7.813	2: 7: 3
K_9IIa	0.990	1.072	1.082	2: 9: 3
K_9IIb	0.140	1.137	0.997	2: 9: 3
KRII	1.206	4.587	3.803	2: 5: 1
KRIII	1.049	0.750	0.714	3: 9: 2
E_1	0.873	69.167	79.238	1: 4: 2
E_2	0.602	42.077	69.942	2:13:10
E_3	0.948	69.600	73.435	3:10: 4
E_4	0.493	78.570	159.280	5: 9: 8
E_5	1.006	41.571	41.324	7:20: 6
E_6	0.373	106.670	285.890	3:10:13
E_7	0.796	26.111	32.801	1: 7: 4
E_8	0.648	34.786	53.665	2: 7: 5
ΔI	0.849	8.904	9.536	1: 6: 3
ΔII	0.767	6.049	7.887	1: 4: 2
ΔIII	0.970	189.000	194.880	1: 4: 2
ΔIV	0.587	2.583	4.398	1: 6: 4

In contrast to the beneficial effect on hardening produced by caustic soda, etc., a retardation was sought in the case of those which showed too high a rate of setting. This was obtained by using sugar solution. The idea for these tests was obtained from a report (Z. ang. Ch. 1923, vol. 36, page 53) in which it was shown that small quantities of sugar have a destructive effect on portland cement. Assuming that this effect was due to the formation of saccharates as assumed by Zulkowsky (T. I. Z. 1902, page 1343), Rebuffat (Gazz. Chim. Ital. 1889), Heldt (Jour. f. prakt. Chem. 1865, vol. 94, p. 144) and Winkler (Jour. f. prakt. Chem. 1856, vol. 67, p. 144) a sugar solution containing 1/100 mole of cane sugar per liter was used with the high calcium melts. As practically no effect was noticed the sugar concentration was doubled. The water requirement dropped about 20% with this solution, and the setting time increased. The strength did not diminish, but, on the contrary, increased. As a combination of sugar with calcium oxide may be assumed, the high lime quick setting mixtures were treated with ½ n hydrochloric acid, but no setting occurred. The water absorption dropped 7 or 8 per cent.

Table IIIb Moduli of melts, which set only with NaOH

	Hydr. Mod.	Alum. Mod.	Setting Mod.	Molecular Ratio SiO_2 Al_2O_3CaO
K_1IIa	1.029	1.061	1.030	2: 3:10
K_1IIb	0.991	1.016	1.026	4: 7:21
K_2IIa	0.730	1.328	1.819	1: 2: 4
K_2IIb	0.746	0.926	1.242	1: 2: 4
K_3IIa	0.780	0.596	0.764	2: 3: 7
K_3IIb	0.808	0.644	0.811	4: 3:10
K_7IIa	0.888	1.181	1.331	1: 1: 3
K_7IIb	1.177	0.664	0.569	3: 2: 9
KRII	1.207	4.587	3.800	2: 1: 5

The melts above the boundary proved to be in a certain sense quick setting. They were stirred up with sugar solution but without success. Consequently the lack of setting power may be due to insufficiency of lime. An attempt was made to secure improvement by stirring with limewater, but this did not help.

To test acid resistance well set examples of all the melts which set properly were put into 10 per cent solutions of $MgSO_4$ and $KHSO_4$. The samplesples in the magnesium sulfate solution showed no change after eight weeks. Except for two, namely, K_9 IIb and KR III all the samples in the potassium bisulfate solution were unchanged. In all other cases the strength seemed to have increased. The attached samples were from melts high in iron. It seems that here, too, the iron oxide content may not exceed certain limits.

These qualitative tests were supplemented by compression tests which according to standard testing procedure were made on cubes 2 cm. on an edge. Cut down with standard sand in the ratio of 1:3 and mixed with somewhat more than the water required theoretically, the cement was forced into the molds with 150 strokes. After three days' storage in moist air the cubes were removed from the forms. The compression tests were carried out after 3, 7, 14 and 28 days with combined storage of the pressure bodies (Table IV). As the fluctuation in size of the pressure bodies from the 50 cm^2 standard surface might produce an appreciable change in the strength values under certain circumstances, tests were made with a standard tested cement. The slight variation found was within the limit of error to be assumed for the inexactness of the testing method.

Table IV

Compression Strengths

	2 days	3 days	6 days	7 days	14 days	28 days
K_5Ia	...	117	...	166	186	194
K_5Ib	...	125	...	127.5	133	153
K_9Ia	...	80	...	55	105	113
K_9Ib	...	30	...	45	76	78.5
K_9IIa	...	145	...	130	125	192
K_9IIb	...	80	...	50	70	111
KRII	...	105	...	122	100	102.6
KRIII	...	37.5	...	41	50	55
E_1	...	...	...	484	...	583
E_2	...	...	...	646	...	801
E_3	...	...	...	305	...	422
E_4	...	...	...	55	...	168
E_5	...	...	...	382	...	474
E_6	...	...	...	146	...	413
E_7	...	...	...	610	...	718
E_8	...	...	...	673	...	952
II	495	...	...	571	...	583
III	344	...	...	418	...	582
IV	...	535	558	...	665	680
V	448	...	...	501	...	707

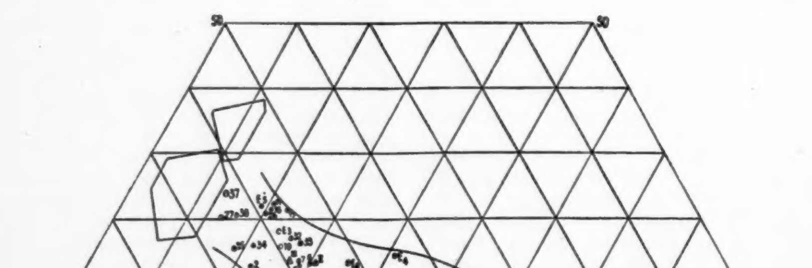


Diagram 4

Molecular Percentages of the Melts According to Endell and of Technical Cements. (Tables IIb and IIc). At the Left the Fields of Portland Cement and Foundry Slags.

(c) The Crystallographic Investigation

For this purpose sections of 19 melts were prepared and examined: these were K_2 Ia+IIa, K_3 Ib+IIa, K_4 Ia+IIb, K_5 Ia+IIa, K_6 Ia+IIb, K_7 Ia+IIa, K_8 Ia+IIb, K_9 Ia, Ib+IIa. Besides, powdered samples of KR I-III and KR VI were prepared.

In general all the pieces had the appearance of blistered iron slags. In a number crystals could be distinctly seen in the bubbles either with the naked eye or with the glass. These apparently belonged, according to the length of edge and angle, to the regular system. In some the fracture showed areas which almost seemed to indicate a structure of regular or hexagonal plates.

In the melts K_2-K_5 it was at first impossible to obtain confirmation. However, K_6II showed well defined crystals which permitted a more exact determination. There were tetragonal cross-sections and rectangular longitudinal sections. The type of slag inclusion was characteristic. On examination it proved that this "mineral" was tetragonal; cleavage perpendicular to prism surfaces, weak double refraction and prismatic structure. Almost all of them showed the same kind of inclusions; from the end surface towards the center there was a large conical or pyramidal inclusion and perpendicular to the prism surfaces there were smaller striations.

The optical properties of the crystals were abnormal. Complete extinction never occurred, but on turning the object only a slight change in color resulted. This very abnormal behavior of the undoubtedly doubly refractive crystals was unmistakable. They were compounds apparently related to gehlenite.

These crystals appeared on more careful examination of all the sections. In addition further small rod shaped crystals and larger crystal skeletons appeared. These behaved abnormally also in polarized light between crossed nichols so that no doubt could exist but that they were compounds of the gehlenite type; the chief branches were perpendicular to each other, whilst the lateral branches were at an angle of 45 degrees and consequently undoubtedly crystals of the gehlenite type. Besides these colorless large crystals, rods and crystal skeletons they were also smaller crystals. These often surrounded the larger individuals, being partly perpendicular to the walls of the former

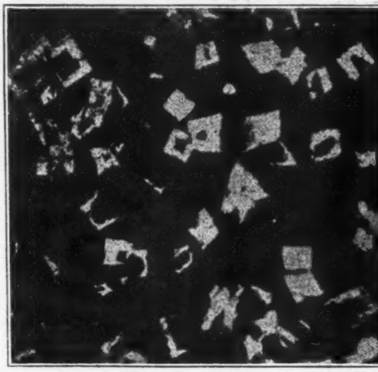


Fig. 1—K_8IIa
Large Crystals of "Melilith" in Dark, Vitreous Ground Mass

or they clustered in nests and veins. Their color was light brown to dark reddish brown. Their optical properties were just as abnormal as those of the larger crystals; only a weak brightening occurred on turning. On very strong magnification many of the small crystals situated within those of large cross section showed tetragonal structure clearly: a four-sided pyramid with the surfaces at right angles, terminated by a flat four-sided pyramid. This latter kind of crystal also belonged to the same group. In addition there were rods of pale brown, greenish or dark blue color. These were especially numerous in the section of K_4 Ia which was built up entirely of such rods which all showed no extinction but only a slight darkening on turning.

It seemed to be an isomorphous series of chemically distinct substances. As a matter of fact section K_8 IIa showed large crystals with a zonal structure in the formation of which all three types participated which should remove all doubt as to the isomorphism of these differently colored compounds. As stated above they belong to the gehlenite group according to their optical properties.

This group according to Tschermak (Lehrbuch der Mineralogie, 1915, p. 567; Doelter, Handbuch der Mineralchemie, p. 933) has as one end member Akermanite ($Ca_4Si_3O_{10}$) and as the other Gehlenite ($Ca_3Al_2Si_2O_{10}$). According to Winchell (Chem. Zntbl. 1925, p. 632) the formulae are $CaO.MgO.2SiO_2$ and $2\ CaO.Al_2O_3.SiO_2$ in which MgO is replaceable by FeO, Al_2O_3 by Fe_2O_3, and in addition K_2O and Na_2 may enter the molecule. The both end members are very variable

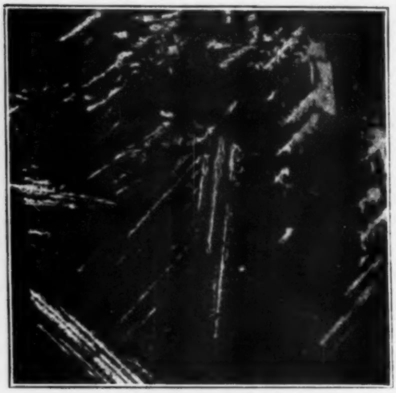


Fig. 2.—K₇Ia
Large Crystal Skeletons in a Vitreous Ground Mass

in their composition, äkermanite is optically positive, gehlenite negative. By isomorphous substitution of these two end members the possibility is produced of chemically differing members, the optical properties of which vary correspondingly.

A number of these bodies may be called Melilith. The blue and green crystals probably result by the substitution of FeO for CaO, the yellow and brown by substituting Fe_2O_3 for Al_2O_3.

Furthermore the sections showed a vitreous ground mass, chiefly of a brown or olive-brown color. Here and there, especially in the melts high in iron oxide, crystals of magnetite appeared and similar spinel bodies of deep dark brown, blue, green and violet color.

The sections of the melts were compared with a technical blast furnace slag, a typical äkermanite slag. The crystals appearing here showed in their optical behavior, structure and cleavage as well as slag inclusions a very considerable agreement with those from the melts.

In addition sections of portland cement were prepared for comparison. These sections showed contrary to assumption not only no great differences from the melts but a very decided similarity. Clusters of red-brown crystals and larger colorless crystals of quite similar abnormal optical character lay in a vitreous brown ground mass. They had cleavage and inclusions similar to those from the melts. More about this in another place.

In the chilled melts the crystalline structure was scarcer; there were only very fine needles and very small cross-sections.

The value of the double refraction could not be determined as the sections in which the cross-sections of crystals were large showed irregular extinction probably due to cooling stresses so that measurements were impossible.

With the change in chemical structure there is a corresponding change in crystallographic structure, determined apparently by the SiO_2. This will be considered more exactly in another place.

Evaluation of the Results

1. The Position of the Cement Field (in the Ternary Diagram)

In diagrams 1 and 2 the points of the mixtures are represented as rectangles. The analyses of the corresponding melts are given in Table Ia in percentages by weight, in IIa in molecular percentages. In the diagram the consecutive numbers only are given to assist in clarity. Diagrams 3 and 4 contain the normally setting melts and those setting with NaOH (double circles), the melts according to Endell with E and a consecutive number (Tables Ib and IIb), the technical cements with Δ and a Roman numeral (Tables IC and Hc). The limits which Endell gives as the probable ones for aluminate cements are given in diagram 3 and recalculated to molecular percentages in diagram 4 together with the corresponding limits for portland cement and foundry slags.

Toward the top these limits seem to go gradually past very rapid setting melts low in Al_2O_3 into the true portland cement region without any sharply defined boundaries such as exist on the sides. The upper limits toward the regions rich in Al_2O_3 and poor in CaO proceed sharply to include the points 11, 16 and 17 which lie exactly on them. The setting tests seem to show that all products outside of these limits have no hardening power as even the "boosting" solutions have no effect. That such points often lie close to the boundaries shows that the separation must be very sharp. In the lower part toward the excessively rapidly setting compounds rich in CaO the separation is not so sharp as above.

The points 2, 3, 6, 7, 10, 11, 26 and 27 are especially interesting. In spite of their favorable position within the limits these compounds do not harden with water. Although the sum of the sesquioxides corresponds to an aluminate cement, the cement fails to set on account of the high content of Fe_2O_3. Endell (Zement 1920, p. 349) has shown that calcium ferrites do not set, just as Winkler had previously shown it.

In the melts KR I-VI (Tables Ia and IIa) which were carried out as controls on these results, the aluminum oxide was displaced by the increasing addition of Fe_2O_3. KR VI contains no alumina. The last three products of this series have no setting power.

It is to be concluded that for technical purposes the iron must be removed as much as possible, but that in cements rich in CaO and low in Al_2O_3 a certain percentage of Fe_2O_3 hinders too rapid setting. This is particularly true for the intermediate region between the aluminate and portland cements, the melts in which can hardly be considered as cements because of their high velocity of setting. However, by additions this can be diminished so that for certain purposes they might still have value.

According to Endell's data and the experiments here reported the whole area should yield technically valuable cements throughout its whole extent with an Al_2O_3 content up to 28-30 per cent, and SiO_2 content up to about 20 per cent. Beyond this lies the intermediate region. Within these values the technical cements tested were also found to lie.

In order to be able to determine the molecular composition the weight percentages were converted to molecular percentages (Tables IIa-IIc, diagrams 2 and 4). The limits of portland cement and foundry slags were introduced in the converted form also.

If we compare the diagrams of the system $CaO\text{-}SiO_2\text{-}Al_2O_3$ with it, it appears that the limits of the conjectural field enclose the three small fields of $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$, and $CaO.Al_2O_3$, the upper limits enters approximately half-way into the lower part of the field $2CaO.SiO_2$ and proceeds by a slightly bent curve toward both the other cement fields. The lower limit proceeds within the upper part of the CaO field, close to the areas $3CaO.Al_2O_3$ and $3CaO.SiO_2$ which lie sufficiently within the limits to extend toward the lowest corner of the portland cement field.

The very broad limits show the immense possibilities which exist in the formation of aluminate cements. In addition FeO and Fe_2O_3 appear as in-

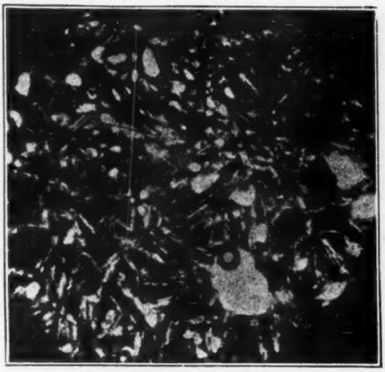


Fig 3.—K_4Ia
Plate Shaped Crystals of "Melilith" in Colorless, Greenish and Blue Modifications

tegral components of technical cements. It would be very difficult to decide which compounds are present and to specify them sharply distinguished from each other.

In the literature many such compounds are calculated from the analyses and even their percentage in the melts indicated. These assumptions seem fairly rash on comparison with the picture yielded by the sections of the melts. This complexity was not observed there. In the presence of various well defined compounds a differentiation in optical properties would undoubtedly appear, but such was not the case. In working with pure chemicals this is the case as has recently been shown again (Zement, 1923, p. 3).

In the technical melts the case is quite different. According to our present experiments only one substance and that of very variable composition crystallizes out, namely, melilith which depending on its analysis may be optically positive or negative or even nearly isotropic. But its appearance and properties are so characteristic that no doubt was possible as to its existence. It is to be supposed that impurities, perhaps especially the TiO_2 content would favor the separation of such substances similar to melilith. The remainder consists of glass and inert spinel bodies.

With increasing content of SiO_2 and Al_2O_3 the amount of melilith seems to increase. This proceeds to an optimum which when exceeded favors the formation of more glass or other crystallizations. This optimum seems to have been reached with K_4Ia and K_6IIa which consists practically entirely of

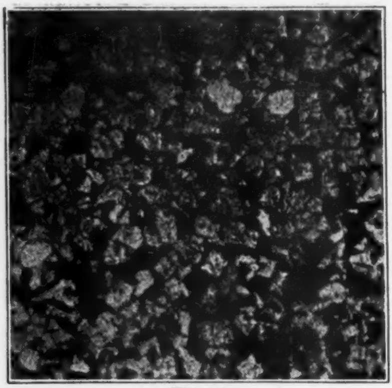


Fig. 4
Typical Technical Akermanite Slags

crystal skeletons and masses and whose molecular ratios are respectively for $SiC_2:CaO:Al_2O_3=3:4:4$ and 3:4:2 and which are situated farthest from the CaO field (diagrams 1 and 2). The line joining these two points should give the limits for the most favorable conditions for the formation of melilith. On one side it stands alone, on the other new substances appear.

Between the portland cements and the aluminate cements lies, as we have stated, the area of the high lime rapidly settling compounds which absorb abnormally large quantities of water but yield low strength values. Their CaO content exceeds 54%, SiO_2 is 22%, Al_2O_3 23-24%. Dilute sugar solutions (1/50 molar) increase the setting time somewhat and improve the strength values which are low.

As portland cement is known to incline to rapid setting with increasing Al_2O_3 content, whereas aluminate cements do so with decreasing Al_2O_3 and with increasing CaO, there appears consequently to be a gradual transition from one cement to the other. The assumption of a transition and a close relation is strengthened by

2. Results of Optical Investigations.

If we compare the pictures of the sections of portland cement clinkers with those of the melts, there is found a far-reaching similarity. The clinkers contained two kinds of crystals. The larger often of quadrilateral cross-section had, similarly to akermanite slags and most of our melts, a large conical slag kernel within them with inclusions perpendicular to the walls and similar cleavage. The double refraction is low so that the blue-gray glistening crystals showed only a slight brightening on turning the object-stand, and all the phenomena were similar to those for the melilith crystals in the melts. According to Dittler (Doelter, Randbuch der Mineralchemie, Vol. I, 2, p. 803) they are belite. Alite according to the same investigation could not be found, nor felite. Celite which according to Dittler and others lies between the former as a dark, yellowish to greenish brown poorly defined mass could clearly be distinguished. On stronger magnification these masses resolved themselves into rounded crystalline grains which showed distinct double refraction between nichols, but similarly to modifications of melilith containing iron did not extinguish, but merely seemed somewhat darker. The entire behavior of belite and celite was so similar to the melilith and akermanite of blast furnace slag that the impression was produced that very closely related bodies were being considered. In the case of belite the possibility is distinctly present of a behavior quite similar to that of akermanite.

As a result of the above considerations it appears that fundamentally there is a close relationship between the portland and aluminate cements which involves blast furnace cements also (Stahl and Fisen, 1922, vol. 2, p. 1158). Nothing will be said as to the chemical structure of these crystals, as due to the constantly varying composition of the cements no well supported conclusions as to chemical structure can be drawn, before we succeed in isolating the components in question from technical melts and sintered products and subjecting them to analysis.

However, the similarity is further confirmed by

3. Phenomena of Setting.

It was assumed that only the vitreous component determined the setting. This assumption was shown by microscopic examination to be justified insofar as these components showed the first changes. Then the crystalline components were attacked, first those containing iron. The entirely colorless crystals remained completely unattacked and remained in the section as clear grains with unaltered properties in samples completely set after 8 weeks. The changes which appear on setting are very similar to those in the case of portland cement. A difference is difficult or impossible to find. The hydrolytically attacked grains surround themselves with a coating of very fine needle-shaped crystals with double refraction and thus form typical spheroliths. The tiny needles form a felt which determines the initial strength. The appearance of these spheroliths is a sign of the beginning of the setting process. Only on slacking with the necessary amount of water to a viscous paste this starts appreciably sooner. This is explained by the various experimental conditions. In the microscopic preparation a considerable excess of water is present which exceeds the amount required many times. Perhaps the phenomena relative to the excess of water are similar to those for excess water with plaster of Paris, for which Le Chatelier found that a recrystallization occurred from a supersaturated solution. Similarly for setting, at least a saturated solution is probably required, and it does not occur or only slowly in the presence of a large excess of water. On this basis the non-setting cements which proved to be very rapid setting with somewhat less than the required amount of water, were described as "soaked."

As the next and last stage we have the formation of a gel, the origin of which and further effects of which could not be exactly observed; for because of the gel the product became so clouded and dull that observation was impossible either in transmitted or by incident light. It must be assumed that it is aluminum hydroxid which originates in the decomposed compounds; for, if we place lumps capable of setting in water for a considerable time, at first a thin skin forms over the surface, then numerous white flakes appear and a fine crystalline coating forms on the walls of the vessel. Qualitative investigation showed the flakes to be principally aluminum hydroxid and the coating of calcium carbonate; the solution reacted distinctly alkaline because of its content of calcium hydroxid.

In order to obtain a picture of the hardened cement, hardened samples were examined in thin sections. The spheroliths which are primarily produced and were recognizable in the aluminum hydroxid when the latter formed, had disappeared as had the vitreous background, only the scales of the quite light, colorless melilith were well preserved in the mass. The varieties high in iron were all more or less attacked and turbid. The small crystals of the spinal bodies were unchanged. This crystalline conglomerate was united by a uniform strongly doubly refractive material. The double refractive indicates an undoubted crystalline structure. The crystals, however, were so small, that even the strongest magnification could not resolve this bright mass, so that a more detailed definition was impossible. Accordingly we have the following picture of the setting; under the influence of water the vitreous substratum first decomposes. Hydrated compounds are formed, which surround the grains as spheroliths and become felted masses of crystals producing the initial strength. With increasing hydrolysis aluminum and calcium hydroxids dissolve as well as some silicic acid. With increasing saturation of the solution the colloidal aluminum hydroxid and silicic acid are floculated by the increasing content of electrolytes, and after neutralization by lime they bind the masses more thoroughly. Simultaneously the alkaline reaction causes the more easily decomposed compounds to be attacked and these enter into the reaction. As the hydroxides and the silicic acid are present in the extremely reactive gel-form, new and, naturally at first, strongly hydrated calcium silicates and calcium aluminiosilicates are formed with correspondingly higher strength values. In time these lose their water or a large part of it, which explains the contraction with gradual hardening. The process of setting and hardening has then reached its final phase.

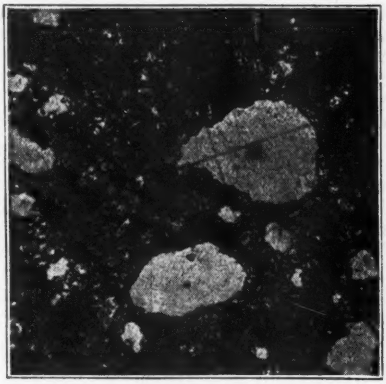


Fig. 5
Portland Cement

The action of caustic soda, which showed such a favorable action in the case of a series of products of high iron content is to be considered as a variety of decomposition. Compounds are formed such as calcium ferrialuminate and calcium ferrialuminiosilicate which are apparently very reactive. Part of the calcium is displaced by sodium and thus soluble compounds are formed and calcium hydroxid is produced. Then the process will go on very similarly to that indicated above.

The action of sugar solution is quite different. As a result of the high lime content and the low alumina content these melts appear to be very reactive. The sugar solution by forming saccharates removes part of the free-lime from solution which reduces the intensity of the reaction. Whether the lime so held again enters into the reaction is difficult to decide. But it is to be expected that these saccharates will be labile toward the new hydrates and will thus return their lime to the process.

The composition of natural cements seems to contradict the idea of the harmfulness of a high iron oxide content. But in this case we have products which lie in the middle of the portland cement area. Even if, as in this case, all the aluminum oxide is replaced by iron oxide, it can produce no such effect as in the case of the aluminate cements for the silicates and not the aluminates play the predominating role. They have in common with the aluminate cements a very high resistance to chemical action.

According to the previously described researches on acid resistance the iron oxide figure should not exceed a certain value. The setting power diminishes with increasing content of iron oxide (Tables Ia and IIa). In order to determine the maximum values of iron oxide and to obtain a useful index the ratio of Al_2O_3 to Fe_2O_3 for all the melts which set, for the products described by Endell, and for the technical cements tested, was determined and called the aluminate modulus ("Al.M.") and proposed for technological practice (Tables IVa and b). An examination of the tables shows that this figure should be not less than 2.

$$\text{Al.M.} = \frac{Al_2O_3}{Fe_2O_3} = 2$$

The hydraulic modulus is not confined to small limits, but it may, according to table IVa properly vary between 0.3 and 1.1. Beyond this point we may produce setting too rapidly such as KRII with a H.M. of 1.2. As the latter is in general a small figure varying but slightly, an additional index for these cements is proposed under the name of setting modulus, "B.M.", (binding modulus), the ratio of Al.M. to H.M. According to Table IVa and b this ratio may assume very large values depending on the magnitudes of Al.M. and H.M. and a more sensitive index is thus obtained: This ratio is always larger than the aluminate modulus.

$$\text{B.M.} = \frac{\text{Al.M.}}{\text{H.M.}}\ \text{Al.M.} = 2.$$

The cements obtained in the above researches unfortunately varied in setting time with age. When freshly made they normally set in 1½-2 hours. After a quarter of a year this figure dropped to approximately 30 minutes. The cause of this change is difficult to determine. Changes due to atmospheric conditions are excluded as the cements were kept in tightly stoppered bottles. It may be assumed that in the course of time a rearrangement occurs which increases the reactivity and thus decreases the setting time. The compression values are quite small (Table IV). But as we are dealing with melts high in iron and as was previously shown calcium ferrites do not set, this is not very astonishing. Furthermore use under water does not seem admissible as in certain cases a sudden deterioration seemed to occur under water (Gehler, Zement, 1924, p. 160). Apparently part of the lime and aluminum hydroxid was leached out as was confirmed in several tests.

Summary

In the present article it was found by fusion experiments and the analytical and crystallo-optical evolution of the products that:

1. The Vogelsberg bauxites may be used like the French bauxites for the production of cement fondu (aluminate cements).

2. In the Gibbs triangular diagram the field of these cements so far as these experiments show is that indicated by K. Endell in his article published in the Records of the Association of German Portland Cement Manufacturers for 1919.

3. The melt is constituted of the crystals of a substance similar to melilith and a vitreous ground mass both of which may vary according to the composition of the melt. Chilling proved to be of minor influence.

4. On the basis of optical investigations and the position and course of the boundaries the close relationship of portland and aluminate cements is indicated. They are not sharply separated but there seems rather to be a gradual transition from one to the other by way of an area of doubtful products which may belong to one type of cement as well as to the other.

5. In the setting process similar phenomena occur to those for the portland cements. The melilith participates in the reactions, depending on its composition.

6. The acid resistance is in general very high. After 8 weeks subjection to the action of a 10 per cent solution of $KHSO_4$ a strong effect occurred only with cements exceptionally high in iron. All the other samples remained unaltered and also in 10 per cent $MgSO_4$ solution. The strength values apparently increased.

7. The compression strength of aluminate cements diminishes after exposure to water.

Newaygo Improves Goodwill by Annual Banquet

Two hundred employees and guests of the Newaygo Portland Cement Company, of Newaygo, Michigan, attended the tenth annual banquet of the concern the evening of March 11. One of the surprise features of the evening was the presentation of gold watches to four employes who had been with the company for more than 25 years and the announcement by General Manager J. B. John that each worker attaining a similar service record would be presented with such a gift.

The twenty residents of the town who were employed by the company during its first year of operation in 1899 were invited and of these 16 were present. The banquet was a get-together affair and was heartily enjoyed by all. The assemblage stood in silence for a minute during the entertainment in memory of Charles H. McGregor, an old and faithful employee who had died since the last banquet.

Mr. John spoke briefly outlining the plans and hopes of the Newaygo company and W. A. Ansorge gave an interesting account of the early years of the operation and its growth from an experimental plant to today's operation. W. J. Bell, the first superintendent told of his 34 years connection with the cement business and compared working conditions in Newaygo with those in larger places.

Bay City Improvements

Important improvements are announced in the construction of the Bay City 16-B excavator. Most noteworthy is the conversion of this popular, all steel excavator into a full crawler machine. In general it is the same Bay City but in full sized shoes, however there are other refinements which while not so conspicuous are never the less highly important. The skimmer-ditcher rope is so located that the operator can reach and operate it, thus doing away entirely with the ground man.

The clutches and bands are slightly enlarged also. The same features which made the half crawler so well liked are retained in the improved model. The full crawler mechanism gives the machine increased propelling speed, greater mobility, better traction, positive steering, and application of power of both treads at turns.

The power plant is a Climax "Trustworthy" 60 h.p. 4 cylinder engine with air cleaner and dash control. A twin disc clutch with thumb adjustments is used. The two main operating drums are grooved for cable, each drum operating on an independent shaft. The drums are bronze bushed.

Band type clutches are used on the hoisting drums and cone type on the swinging and propelling. They can be adjusted instantly. The machine has three operating control levers, one for each drum and one for swing. Both the propelling lever and the clutch control are within easy reach of the operator's seat, which is adjustable.

Harnischfeger Appoints

The Harnischfeger Corporation, manufacturers of gasoline excavators and trenching machines, announce the appointment of the Clark-Wilcox Company, 17 Lafayette Street, New Haven, Connecticut, and also at 786 Albany Street, Boston, Massachusetts, as agents in place of the K. B. Noble Company of Hartford, Connecticut. William H. Hale Company have been named agents in Minnesota with headquarters at 607 Fifth Avenue, South, Minneapolis.

Recent Patents

The following patents of interest to readers of this journal recently were issued from the United States Patent Office. Copies thereof may be obtained from H. E. Burnham, patent and trade-mark attorney, Continental Trust Building, Washington, D. C., at the rate of 20c each. State number or patent and name of inventor when ordering.

1,572,870. Clutch. Edwin J. Armstrong, Erie, Pa., assignor to Erie Steam Shovel Co., Erie, Pa.

1,573,032. Ore-grinding mill. William N. Beyerle, Mesa, Ariz.

1,573,128. Bucket for excavators. Walter Baker, Fairfield, Iowa, assignor to Speeder Machinery Corporation, Fairfield, Iowa.

1,573,130. Self-righting bucket. Homer W. Benton, Harvey, Ill., assignor to Whiting Corporation, Harvey, Ill.

1,573,191. Pulverizing-mill. Fred I. Raymond, Evanston, Ill., and William B. Senseman, Los Angeles, Cal., assignors to Raymond Brothers Impact Pulverizer Co., Chicago, Ill.

1,573,564. Mining-machine. Hess P. Morgan, Lisbon, Ohio.

1,574,142. Gratory crushing-machine. William S. Weston, Columbia, S. C.

1,574,247. Excavator. Arthur M. Hood, Indianapolis, Ind.

1,574,248. Slack-line excavator. Arthur M. Hood, Indianapolis, Ind.

1,574,421. Apparatus for making concrete pipe. Clare H. Bullen, Portland, Ore., assignor to Tuerck Mackenzie Machine Co., Portland, Ore.

1,574,433. Concrete-pipe-bend machine. William J. MacKenzie, Portland, Ore.

1,574,436. Pulverizer-beater. Stanton C. Martin, Erie, Pa., assignor to Erie City Iron Works.

1,574,444. Lip and teeth for excavating-buckets. Nazro H. Reynolds, Oakland, Cal.

1,574,492. Dipper-trip. Werner Lehman, Fred J. Brewer, and Roger S. Hoar, South Milwaukee, and Benjamin F. Johnston and Mitchell L. Fykse, Milwaukee, Wis., assignors to Bucyrus Co., South Milwaukee, Wis.

1,574,597. Machine for forming cement blocks. Joe Bocchino, Utica, N. Y.

1,574,612. Cement-block mold-box. Robert A. Eaton, Haddon Heights, N. J.

1,574,720. Block-shaping machine. Sherburne H. Weighman and Thomas A. Long, Chicago, Ill., assignors to International Concrete Industries Corporation, Chicago, Ill.

1,574,763. Dipper-trip. Paul S. Stevens, South Milwaukee, Wis., assignor to Bucyrus Co., South Milwaukee, Wis.

1,574,920. Mining apparatus. Richard E. Murphy, California, Pa., assignor to Sullivan Machinery Co., Claremont, N. H.

1,575,431. Coal-mining machine. Nils D. Levin, Columbus, Ohio, assignor to Jeffrey Mfg. Co., Columbus, Ohio.

1,575,452. Pulverizer-beater. William H. Shave, Erie, Pa., assignor to Erie City Iron Works.

1,575,457. Screen. Albert H. Stebbins, Los Angeles, Cal.

1,575,601. Screening device. Curt G. Knoblauch, Chicago, Ill.

1,575,719. Gravel-screening apparatus. Carl Sandberg, Battle Creek, Mich.

1,575,874. Crushing-head. Edgar B. Smons, Los Angeles, Cal., assignor to Symons Brothers Co., Milwaukee, Wis.

1,576,430. Screen separator. John F. Isbell, Alhambra, Cal.

1,576,438. Method of testing the consistency of concrete. Frank H. Jackson, Washington, D. C. (Dedicated to the public.)

Ohio Sand and Gravel Men Meet

An enthusiastic meeting with practically every member in attendance was held by the Ohio Sand and Gravel Producers Association at Columbus, March 18th. Talks were made by George F. Schlessinger, state highway director for Ohio; H. J. Kirk, chief engineer of the Ohio State Highway Department; R. J. Stimson, chief engineer for the city of Columbus and C. Lattimer, surveyor of Franklin County.

The following officers were elected: President, Earl Zimmerman, Ohio Gravel Ballast Company, Cincinnati; vice president, F. C. Fuller, Portsmouth Sand and Gravel Company, Portsmouth; secretary-treasurer, Stephen Stephanian, Arrow Sand and Gravel Company, Columbus; executive secretary, Guy C. Baker, Greenville Gravel Corporation, Greenville. Those named for the board of directors were: K. K. Kutz, Massillon; T. J. Adams, Columbus; R. A. Ault, Piketon; R. E. Doville, Toledo; L. K. Warner, Marion.

Changes in the 1926 Income Tax Law

By M. P. Snow, M. P. Snow and Company

If this summary of income tax changes shows that the return you filed March 15th was erroneous or disadvantageous to you, you have the right to file an amended return until your case becomes outlawed by the statute of limitations. If you file an amended return immediately, you have the right to recompute your quarterly installment tax payments. To file an amended return, make out a new return, mark it "Amended Return" and file it with the Collector of Internal Revenue for our district.

Appeals—New Procedure—Vitally important changes made as to procedure to be followed in appealing to Board; to courts; as to jurisdiction of Board; cases pending before Board at time new law was passed, jeopardy assessments, etc. Impossible to cover them all here but details will be furnished by author where desired. One of most important changes provides that the Board in re-determining deficiency may consider such tax with relation to the taxes for other taxable years as may be necessary to ascertain the amount of the deficiency for the year in question. But, the Board cannot determine whether or not the tax for any other taxable year than the one under consideration has been overpaid or underpaid.

Amortization—Amortization deduction permitted for years 1918, 1919, or 1920 if claim was made before June 15, 1924.

Automobile Trucks and Accessories—Tax on bodies and chassis repealed, effective on enactment of new law. Tax on other autos and motor vehicles and upon tubes, tires, parts, accessoriess cut from 5 to 3 per cent, effective 30 days after passage of law.

Capital Gains and Losses—New act legalizes an important rule set forth in the regulations interpreting the 1924 tax law. The rule stated that where property is exchanged for other property and no gain or loss is recognized and where the period during which the original property and that received in exchange have been held by the taxpayer is more than two years, the property received in exchange is considered to be capital assets. Same thing is true of property received in connection with a partially exempt exchange. A new requirement of the 1926 act provides that where the taxpayer sells property which has the same basis for gain or loss in whole or in part, as it would have in the hands of a preceding owner, the two-year period includes the period during which the asset was held by the preceding owner.

Stock or securities distributed to shareholders in a corporation a party to a reorganization entails no gain to distributee. In figuring the length of time taxpayer has held stock or securities received in such distributions, there is included the period he held them in the distributing corporation prior to the distribution.

Capital Stock Tax—Repealed effective June 30, 1926.

Cereal Beverage Tax—A 1/10th of 1 per cent tax per gallon on cereal beverages effective with passage of new tax law.

Corporation Tax Higher—A flat tax of 13 per cent for 1925 and 13½ per cent for latter years replaces the 12½ per cent corporation rate. Corporations may pay installments; first installment 24 per cent of the tax; second installment 24 per cent; third installment 26 per cent of tax; fourth installment 26 per cent of tax.

Date Effective—Parts of the new tax law relating to changes in the income tax are in general effective January 1, 1925. Portions of the law relating to other than income taxes are effective as shown under each different kind of tax, such as estate tax, capital stock tax, etc.

Depreciation For Life Tenant and Remainderman—Provision made for depreciation to be apportioned between life tenant and remainderman in case of improved real estate.

Dividends—Liquidation—Under the 1926 law if a corporation cancels or redeems its stock (whether or not the stock was issued as a cash dividend) in such way and at such time as to make the distribution or cancellation wholly or partly equivalent to the distribution of a taxable dividend, this amount to the extent that it represents a distribution of earnings or profits accumulated after February 28, 1913, is treated as a taxable dividend. The law qualifies this by saying that in the case of the cancellation or redemption of stock not issued as a stock dividend this applies only if the cancellation or redemption is made after January 1, 1926.

Earned Income—Maximum amount that may be considered earned income is increased to $20,000.00 Earned income credit may not exceed 25 per cent of normal tax plus 25 per cent of the surtax which would be payable if the earned income constituted entire income.

Estate Tax—Not repealed, but rates reduced. Exemption $100,000 instead of $50,000 under old law. Rates of 1921 law substituted for those of 1924 tax act affecting the year 1924. Taxpayers dying between date of enactment of 1924 law and before its repeal by new 1926 law have exemption of only $50,000. Credit is allowed for state inheritance taxes of not more than 80 per cent of Federal Estate Tax. Charitable bequests do not under new law have to be reduced by amount of state or inheritance tax as payable out of these bequests. Applies to estates of taxpayers dying subsequent to enactment of 1924 tax act.

Exemptions and Credit—Married persons and heads of families $3500.00 (regardless of amount of net income); single persons $1500.00; dependents $400.00.

Exempt Corporation—Certain Mutual insurance companies and co-operative associations are given complete exemption.

Extension—For Filing Return—General extension may be granted by Commissioner.

Gain or Loss, Determination of—New law requires taxpayer to make an adjustment for depreciation, obsolescence, etc., in figuring Gain or Loss on a sale or other disposition of property; that is, for instance, depreciation allowable but not taken due to the fact that no return was filed.

Gift Tax—Repealed, effective as of January 1, 1926.

Individual Rates—Reduced from 2 per cent to 1½ per cent on the first $4,000.00; from 4 per cent to 3 per cent on the second $4,000 and from 6 per cent to 5 per cent on the rest of the net income.

Interest on Deficiencies—Deficiencies for years before 1921 draw interest at 6 per cent from the date of the enactment of the new law to the date of the tax is assessed. Or, if a waiver of right to appeal to Board is filed, it runs to the 30th day after the filing of the waiver or to the date deficiency is assessed, whichever is earlier. If the assessment was made before June 2, 1924, interest starts at enactment date of the 1926 law and runs to the date of notice and demand from collector, or, in case taxpayer filed a waiver of his right to appeal to Board, interest runs to the 30th day after filing waiver or to date of notice and demand, whichever is earlier.

Interest—Refunds and Credits—In case of a claim for credit against an additional tax assessment made under 1921, 1924 and 1926 laws, interest is allowed to date of assessment of the additional tax. Interest allowed on credit for overpayment under 1918 law and earlier acts only to date on which original tax against which credit is claimed was due except where amount against which credit is asked is an additional assessment under 1921, 1924 or 1926 laws. Where interest is granted to "date of the allowance of refund," term means first date on which commissioner signs schedule of overassessment.

Invested Capital—New law legalizes the practice of the Tax Administration which required in the excess profits tax years that invested capital be reduced by pro-rata portion of income and excess profits tax paid for preceding year.

Installment Basis of Reporting—New act approves installment method reporting taxes, allowed previously by the tax administration but not specifically covered by old law. A person who regularly sells or otherwise disposes of personal property on the installment plan is permitted to file on the installment method. That is, he reports that proportion of installment payments actually received in a given year which the total profit realized or to be realized bears to the total contact price. In the case of what the tax law calls a "casual" sale or other casual disposition of personal property for a price of more than $1,000.00 or in case of a sale or other disposition of real property, if in either case the initial payments do not exceed one-fourth of the purchase price, the income may be returned on the installment method. "Initial Payments" according to the new law, mean payments received in cash or property other than evidence of indebtedness of the purchaser during the taxable period in which the sale or other disposition is made.

Installment Sales—Refunds—Right to report on installment plan is retroactive. Applies to tax laws of 1916, 1917, 1918, 1921, 1924. Where a taxpayer has paid more in taxes than he would have paid under the installment scheme, he is permitted a credit or refund, if the Statute of Limitations has not run against him.

Interest—Deficiencies—Interest on a deficiency—where tax was paid in installments—runs from date on which first installment was due. Where taxpayer filed a waiver of his right to appeal to Board, interest runs to 30th day after waiver was filed or to date deficiency is assessed, according to which is earlier.

Insurance Companies—Continue to pay 12½ per cent under new law.

Insurance Policies—Proceeds of life insurance policies under new law exempt regardless of whether in one amount or installments. If amounts are held by insured under an arrangement, to pay interest, these interest payments are not exempt.

Narcotic Tax—Cut from $3.00 to $1.00 per annum on dispensers of drugs.

Personal Service Corporation—Stockholders who paid taxes on their distributive shares of the income in a corporation which was afterwards refused personal service classification and assessed with taxes too late for the stockholders to file claims for refund are given relief under the new law. In such a case, a claim for refund may be filed by the stockholder within the statutory period or within one year after the enactment of the new act.

Real Estate—Reserve for Expenses—In the case of individuals disposing of real estate, allowance is made for deduction of future expenses required under contract of sale, provided bond is filed.

Refunds and Credits—Limitation—Unless the commissioner decreases invested capital because taxpayer did not take proper deductions in prior years; unless the taxpayer has appealed to the Board after passage of the tax law or unless waivers have been filed, no refund of taxes imposed by the new tax law may be made unless claim for refund is filed within three years from the time tax was paid or in case of prior laws, unless claim filed within four years after tax was paid.

Refunds—Board of Tax Appeals—Board not granted jurisdiction of refund and credit claims but on a case appealed to the Board, it may determine amount of any overpayment. After Board's decision becomes final, refund or credit claims are to be filed in proper time.

Refunds—1920 and 1921—If, on or before June 15, 1926, taxpayer files a waiver for 1920 or 1921, he has to April 1, 1927, to file claim for credit or refund. Time may be further extended to April 1, 1928, if waiver filed June 15, 1926, is extended before it expires by a new waiver or by extending the original one.

Returns—Consolidated, Personal, etc.—For 1926 and later years, affiliation exists in the case of two or more domestic corporations, if one corporation owns at least 95 per cent of the stock (not counting non-voting stock, limited and preferred as to dividends) of the other or others; or if at least 95 per cent of the stock (with same qualifications as above) of two or more corporations is owned by same interests. Information returns must be filed where income paid amounts to $1500.00 or more during the year, or $3500.00 or more a year if the payee is known to be married. No return required of married person living with husband or wife if combined net income is less than $3500.00; or combined gross income is not $5,000 or more, regardless of net income. Single person or married person not living with husband or wife does not have to file if net income is less than $1,500 or gross income is not $5,000 or more.

Surtax Rates—Run from 1 per cent to 20 per cent. Exactly same as old, 1924, law up to $24,000. Between $24,000 and $28,000 rate is 7 per cent. Increases at 1 per cent for each $4,000 up to $64,000. On amount between $64,000 and $70,000 rate is 17 per cent. Between $70,000 and $80,000 rate is 18 per cent. Between $80,000 and $100,000 it is 19 per cent. Over $100,000, 20 per cent.

Stamp Tax—Effective as of June 30, 1926, stamp taxes repealed upon deeds or conveyances, proxies, powers of attorney, entry of goods at customhouse and entry for withdrawal of goods from customs bonded warehouse.

Portland Cement Statistics for February

Production, shipment, and stocks of finished Portland cement, by districts, in February, 1925 and 1926, and stock in January, 1926, in barrels

Commercial District:	Production February 1925	Production February 1926	Shipments February 1925	Shipments February 1926	Stocks at end of February 1925	Stocks at end of February 1926	Stocks at end of January 1926
Eastern Pa., N. J. & Md.	2,486,000	2,447,000	1,490,000	1,137,000	4,746,000	5,115,000	3,805,000
New York	272,000	288,000	206,000	145,000	1,233,000	1,590,000	1,447,000
Ohio, W. Pa. & W. Va.	593,000	739,000	404,000	402,000	1,977,000	2,792,000	2,455,000
Michigan	453,000	288,000	254,000	237,000	1,185,000	2,045,000	1,994,000
Wis., Ill., Ind. & Ky.	1,240,000	775,000	601,000	649,000	3,547,000	3,700,000	*3,574,000
Va., Tenn., Ala. & Ga.	919,000	1,029,000	780,000	937,000	869,000	1,058,000	966,000
Eastern Mo., Ia., Minn. & S. Dak.	499,000	483,000	389,000	396,000	3,248,000	3,066,000	*2,979,000
Western Mo., Nebr., Kans. & Okla.	388,000	361,000	468,000	518,000	1,498,000	1,399,000	1,556,000
Texas	339,000	393,000	374,000	400,000	843,000	495,000	502,000
Colo. & Utah	141,000	67,000	110,000	96,000	372,000	244,000	273,000
California	733,000	743,000	786,000	765,000	472,000	511,000	533,000
Oreg., Wash. & Mont.	192,000	118,000	153,000	138,000	407,000	478,000	498,000
	8,255,000	7,731,000	6,015,000	5,820,000	19,897,000	22,493,000	*20,581,000

*Revised.

Production, shipments, and stocks of finished Portland cement, by months, in 1925 and 1926, in barrels.

Month	Production 1925	Production 1926	Shipments 1925	Shipments 1926	Stocks at end of month 1925	Stocks at end of month 1926
January	8,856,000	*7,887,000	5,162,000	*5,672,000	17,656,000	*20,582,000
February	8,255,000	7,731,000	6,015,000	5,820,000	19,689,000	22,493,000
March	11,034,000	....	10,279,000	....	20,469,000	....
1st quarter	28,145,000	....	21,456,000	....	....	....
April	13,807,000	....	14,304,000	....	19,877,000	....
May	15,503,000	....	16,735,000	....	18,440,000	....
June	15,387,000	....	17,501,000	....	16,409,000	....
2nd quarter	44,697,000	....	48,630,000	....	....	....
July	15,641,000	....	18,131,000	....	13,896,000	....
August	16,419,000	....	18,383,000	....	11,952,000	....
September	15,939,000	....	17,711,000	....	10,247,000	....
3rd quarter	47,999,000	....	54,225,000	....	....	....
October	15,992,000	....	15,309,000	....	10,979,000	....
November	13,656,000	....	10,187,000	....	14,534,000	....
December	*10,713,000	....	*6,917,000	....	*18,365,000	....
4th quarter	40,361,000	....	32,413,000	....	....	....
	161,202,000	....	156,724,000	....	....	....

*Revised.

Imports and exports of hydraulic cement, by months, in 1925 and 1926

Month	Imports 1925 Barrels	Imports 1925 Value	Imports 1926 Barrels	Imports 1926 Value	Exports 1925 Barrels	Exports 1925 Value	Exports 1926 Barrels	Exports 1926 Value
January	231,258	$ 364,196	360,580	$576,717	71,596	$ 207,547	72,939	$216,431
February	119,077	206,308	(b)	(b)	56,249	181,356	(b)	(b)
March	218,048	337,039	......	......	65,248	200,410	.....	......
April	197,686	280,826	......	......	89,508	263,831	.....	......
May	186,897	286,959	......	......	85,385	250,845	.....	......
June	254,937	409,539	......	......	71,343	217,899	.....	......
July	335,118	499,602	......	......	98,141	286,543	.....	......
August	379,847	611,551	......	......	103,961	289,904	.....	......
September	513,252	789,121	......	......	102,649	285,225	.....	......
October	535,050	824,268	......	......	73,369	228,467	.....	......
November	388,604	678,518	......	......	101,825	294,201	.....	......
December	295,543	526,001	......	......	100,323	296,900	.....	......
	3,655,317	$5,813,928	......	......	1,019,597	$3,003,128	.....	......

Domestic hydraulic cement shipped to Alaska, Hawaii, and Porto Rico, in January, 1926 a

	Barrels	Value
Alaska	311	$ 934
Hawaii	15,991	34,719
Porto Rico	10,271	25,118
	26,573	$60,321

a Compiled from records of the Bureau of Foreign and Domestic Commerce and subject to revision.

b Imports and exports in February, 1926, not available.

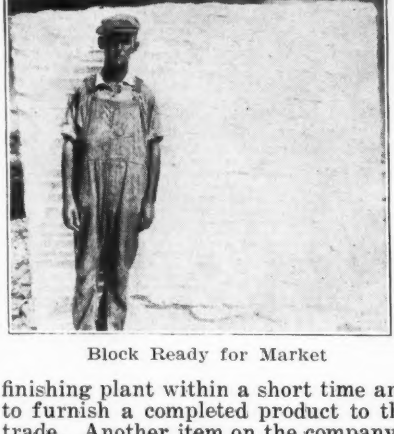
Taking Advantage of Nature

TENNESSEE marble is extensively used as a building material all over the United States. It has invaded Wall Street where the famous bank building of Morgan and Company is constructed entirely of this material, and it is used in public building and office structures from the Canadian border to the Rio Grande and as far west as the Pacific coast.

The popularity of this material from the south land is due primarily to its beautiful colors which run from light pink to deep variegated shades. The earth's convulsions which brought marble to the top in Tennessee generally tilted the rock so that quarrying had to be done at difficult angles. Some marble quarries in the state tilt as much as forty-five degrees, but along the Keller bend of the Tennessee River, near Knoxville, Nature laid a level and undistrubed outcrop.

It is at this spot that the Farragut Marble Company obtained 135 acres of land in one of the best marble deposits in the entire state. It is located in the heart of a light pink vein which has a nation wide reputation. The deposit at a conservative estimate contains at least a billion cubic feet. It is remarkably clear of veins or crows feet as is attested by the fact that within a few weeks after operation was started last summer, the quarry had produced some of the best building stone in the state.

At present the Farragut Company produces nothing but rough quarry blocks but it expects to construct a



Block Ready for Market

finishing plant within a short time and to furnish a completed product to the trade. Another item on the company's program of expansion is the development of another section of the property which will produce a darker and more variegated colored stone.

The quarry is steam operated and only straight drilling and channeling are required because of the level nature of the deposit. The steam is furnished by a 150 h.p. steel encased Casey & Hedges boiler and the power for the drills is generated by a Sullivan air compressor. Four Sullivan drills, three Ingersoll Rand "Sergeant" type drills and two Denver Rock Drill jack hammers are used, together with two Sullivan channeling machines for cutting the blocks.

The rock is taken out by a 100-foot

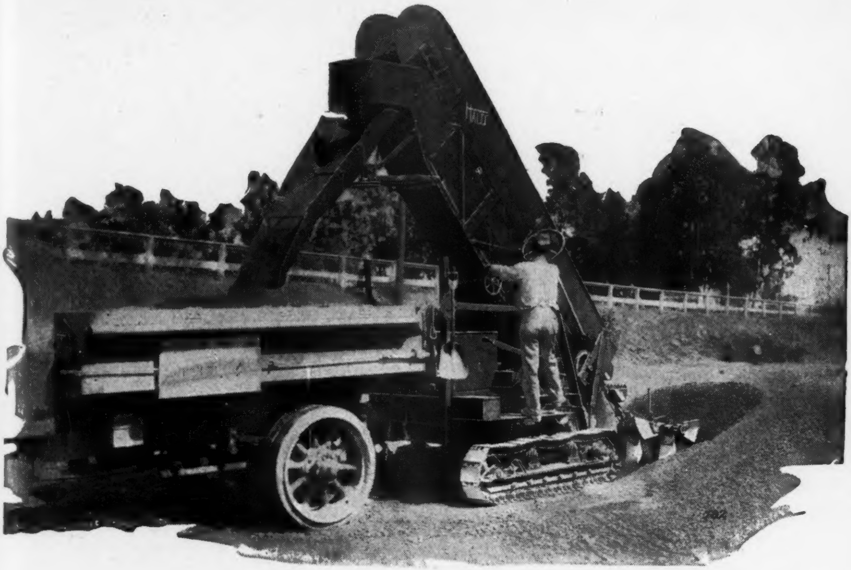
Original Outcrop Before Marble Has Been Removed

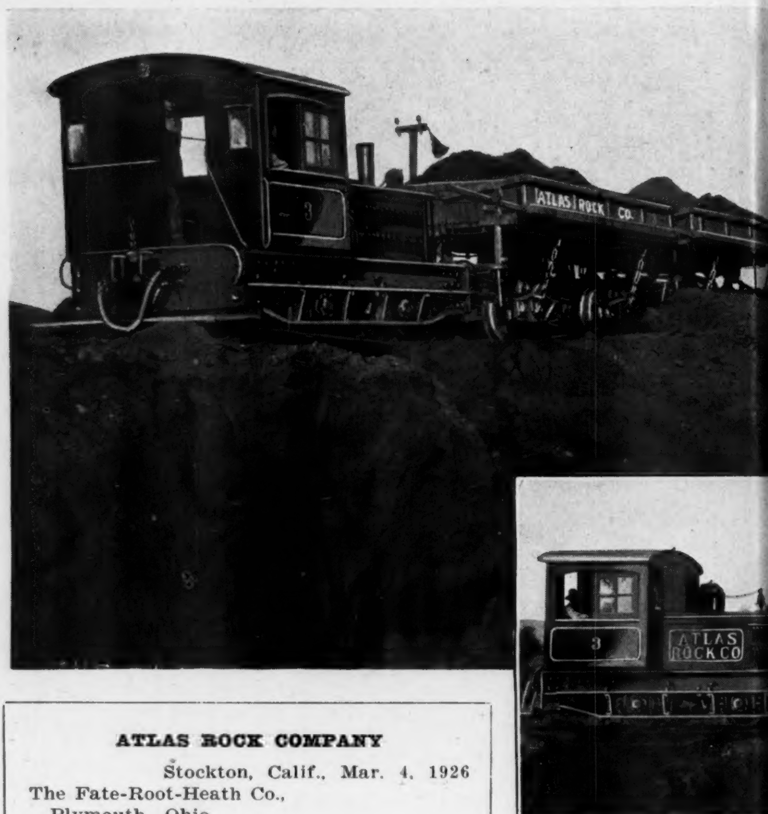
Block Ready for Shipment to Finishing Mill

steel derrick with an 8¼x10 American hoist and a 50 foot wooden derrick with a Flory hoist.

The Farragut Marble Company was incorporated in March, 1923, but did not begin operations until last year. The company has a capital stock of $200,000. The officers of the company are old marble men, S. A. Rodgers, the president and superintendent of the operation has been identified with the marble business in Tennessee for the past thirty years and has opened some of the best producing quarries in the Knoxville district. J. M. Brenneis, vice-president and treasurer, has been interested in marble production for 15 years and was formerly connected with the Gray Knox Marble Company.

Drilling In on Solid Ledge of Marble





ATLAS ROCK COMPANY

Stockton, Calif., Mar. 4, 1926

The Fate-Root-Heath Co.,
Plymouth, Ohio.

Gentlemen:

Our Plymouth 18-ton Gasoline Locomotive is giving wonderful service and will outpull our 21-ton steamer.

The Plymouth is hauling three Western-Air-Dump cars, each loaded with 25 tons of gravel, total weight of cars and load 135 tons, up 1¼% grades with 30 degree curves. The haul is one mile long, and we make about 2½ trips per hour. We could do better than this if we could load faster.

Accurate cost records show average daily cost of operation, including fuel, labor, repairs and every charge against each unit as follows:

21-ton Steamer, .04183 cents per ton hauled.
18-ton Plymouth, .02703 cents per ton hauled.

Very truly yours,

ATLAS ROCK COMPANY,
(Signed) by Fred R. Beerman,
Gen. Mgr.

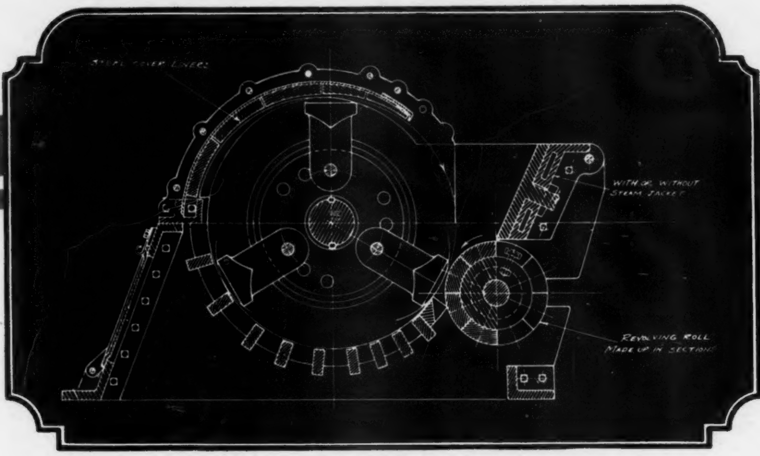
Plymouth 18 Locor

Plymout om

Every da arger
Gasoline h
Every day outh
Because P are
powerful—they
The Plym h pi
Made in 3 sizes
Write for

THE F OO

Gasoline **PLYM**



(PATENTED)

The Williams "NON-CLOG" Crushes Wet Rock, Clay and Shale Without Choking

Read What These Users Say

"Williams hammer crusher with roller breaker plate has given satisfactory service handling material which in rainy weather becomes quite sticky."

Boone Brick, Tile & Paving Co., Boone, Iowa.

"Our shale has a high moisture content at all seasons of the year. Other types of equipment would clog up, but we have had no such trouble since installing our Williams."

Gunderson Brick & Tile Co., Zumbrota, Minn.

"No. 7 Williams crusher working under very severe conditions in size of feed, moisture content and hardness of rock, as our material is always wet and the clay sticky. However, its operation is very satisfactory."

St. Lawrence Brick Co. Laprairie, Quebec, Canada

The letters to the left prove that the "NON-CLOG" has long ago passed the experimental stage in the crushing and grinding of wet rock, clay and shale without choking. For the difficulties of reducing sticky wet material in the clay industry are generally regarded as the worst encountered.

Any type Williams hammer crusher can be furnished with this improvement.

No Openings Into Which Rock Can Wedge and Pack

The Williams "NON-CLOG" revolving roll replaces the usual stationary flat breaker plate. This roll keeps the material constantly agitated. It is also cleared by a scraper on each revolution which eliminates all possibility of the wet material accumulating and building.

No Extra Drive Needed

The revolving roll is driven from the main crusher shaft with a silent chain drive completely encased to exclude dust and dirt.

Williams Patent Crusher & Pulv. Co.

802 St. Louis Ave. St. Louis, Mo.

Chicago 37 W. Van Buren St. | **New York** 15 Park Row | **San Francisco** 415 5th Street

Williams

ORIGINAL PATENTEES AND WORLD'S LARGEST BUILDERS OF HAMMERMILLS

THE WILLIAMS PATENT CRUSHER & PULVERIZER CO. ST. LOUIS, U.S.A. TRADE MARK

REG. U.S. PAT. OFF.

PATENT CRUSHERS GRINDERS SHREDDERS

The Manufacture of Portland Cement* Developments Since the War

By Dr. Paul Hansel of Lobsitz

Investigations into Constitution

THE concept of portland cement has been defined only technically and not with any finality scientifically. Even the technical definitions leave a considerable possibility of variation in the properties of the product and vary in different countries though not fundamentally. They all are based on the process of manufacture and give no proper picture of the constitution. This is due chiefly to the fact that chemical analysis, owing to the decomposibility of the product, indicates only what elements are present in portland cement but not in what compounds they are present and how these interact during the setting. Owing to the great value in national economy of portland cement as the most important structural material of the present time, it is natural that the producers and users, due to the lack of a scientific constitutional formula, have united on the process of manufacture and the properties which portland cement should show in use. In all civilized countries there are associations of producers and consumers which have submitted their requirements and desires with respect to portland cement, chiefly to those governmental institutions which are engaged in the testing of materials and the applications of structural materials, and the result of these negotiations are the so-called "Standards for Uniform Testing and Delivery of Portland Cement" which generally also contain a definition of the latter. This definition generally states: portland cement is a hydraulic binding medium which results from the calcination of an artificial, finely divided (ground) mixture of lime, silica and alumina to sintering, in which the product of calcination, the so-called clinker, must again be finely ground. The ratio of calcium oxide to the combined amount of silica, alumina and iron oxide should be at least 1.7 (hydraulic modulus). In addition certain upper limits are set for minor constituents to obtain important properties of portland cement, of which the content of sulfuric anhydride and magnesia are to be emphasized.

With this explanation of the concept, the manufacture of portland cement is practically determined, but it does not suffice to indicate its properties in a suitable manner, and so there appears in the "standards" a number of determinations of strength, fineness, setting properties, permanence of volume, the standard sand of importance for strength determinations, the testing apparatus, etc. without giving more than superficial indications for scientific investigation of the nature of portland cement from the chemical and physical point of view. This state of affairs is natural for we are dealing with a very complicated structure the investigation of which has been entirely unsuccessful up to the present time. It is, therefore, an outstanding service of the German portland cement industry to have been the first organization of producers to demand of its members the meeting of certain standards by careful investigation and testing and to have thereby ensured the consumer that they had controlled the maintenance of their standards of manufacture through a special laboratory and they exclude every member who failed to meet these requirements. This very important improvement in the production of the entire industry is due to the work and organization of eminent technologists and scientists of whom the names may be mentioned of Dyckerhoff, Schott, Goslich, Müller, Framm, Michaelis, Martens and Gray.

The scientific incompleteness of this aid has always been obvious to the leading cement producers and scientists and they have made important efforts to approach the problem of the nature of portland cement from the purely scientific aspect. This chapter of silicate chemistry has not yet been concluded and although research has explained a number of phenomena and has prepared a large number of chemically and physically clearly defined substances, yet up to the present none of the numerous theories of the significance of these compounds in the

*Translated from article in Zeitschrift fur Angewandte Chemie by Albert P. Sachs, Technical Director, Universal Trade Press, exclusively for Pit and Quarry.

preparation and use of portland cement has been completely confirmed.

Cement investigation is concerned chiefly with two problems, namely: Which compounds exist in portland cement clinker? and the other: what part do the compounds found play in the setting process of portland cement? The available theories must be sought in the appropriate literature.

A comprehensive compilation to the year 1905 is to be found in Dr. O. Schmidt's "Portland-Zement," K. Wittwer, Stuttgart, 1906. The most important works are Vicat on "Hydarulic Lime," 1818, Fuch on "Hydraulic Mortar" 1829; Michaelis "The Hydraulic Mortars," 1869; LeChatelier, Annales des Mines 1887 II. p. 345· Zulkowsky "The Setting Theory of Hydraulic Cements," Gaertners Verlagsbuchhandlung, Berlin 1901; Törnebohm "The Petrography of Portland Cement," Stockholm 1897; Newberry, Tonind-Ztg. 1898; Rebuffat, Gazz. Chim. Ital. 1898; O. Schott, Doctoral Dissertation, Heidelberg, 1906; the Publications of the Carnegie Institute; Z. anorg. Ch. 92 (1915)) E. Jänecke, Z. anorg. Ch. vols. 73, 74, 76, 89, 93; G. A. Rankin and E. Wright, Z. anorg. Ch. vol. 75, Kanter, Schott, Wetzel, Endell and Jänecke, Prot. d. Ver. dtsch. Portland-Zement-Fabrikanten from 1909 on.

As chemical analysis could lead to no goal in determining the constitution of the compounds present in portland cement owing to the reactivity of portland cement toward water and various reagents, most investigators started out from the idea that the principal constituents of the raw material for portland cement, namely, lime, enters into more or less complicated combination with the other constituents, namely, silica, alumina and iron oxide, and they attempted to prepare these compounds of lime with silica, alumina and iron oxide chemically pure by synthetic means and to test these compounds for cementing properties, especially their hardening with water, constancy of volume and strength. Parallel to this there was the petrographic examination of the clinker and comparison with the above described artificial compounds. Le Chatelier and Törnebohm determined that four types of crystals appear in portland cement. Törnebohm named these four crystals alite, belite, celite and felite and practically the entire investigation of constitution of the recent decades has centered around preparing these crystals pure by synthetic means and comparing their properties with those of portland cement. After it was determined by Newberry and Rebuffat that Al_2O_3 and Fe_2O_3 could replace each other in portland cement, the efforts were concentrated on the system $CaO-SiO_2-Al_2O_3$ within which it was expected to determine alite, the chief constituent of portland cement.

Zulkowsky in his work on the theory of setting of hydraulic cements had expressed his opinion that there were two modifications of SiO_2 of which the ortho-silicic acid forms an unstable, dicalcium silicate, while the metasilicic acid forms a stable, hydraulic dicalcium silicate. Meta-calcium disilicate can be detected only by strong chilling of the charge before its conversion into the unstable form.

He considered the compound $2CaO.SiO_2$, meta-dicalcium silicate as the most important component of portland cement, denied the presence of tricalcium silicate which Le Chatelier had designated as the active component of portland cement. Schott (Dissertation, Heidelberg, 1906) expresses the opinion that the chief constituent of portland cement is a double compound of dicalcium silicate and dicalcium aluminate, in which a certain percentage of lime is dissolved.

Newberry and Schmidt (Tonind.-Ztg. 1903) prepared tricalcium silicate and reported like Le Chatelier that it was identical with the alite of the portland cement clinker. Finally Jänecke (Z. anorg. Ch. vols. 73, 89, 92, 93) reported that a compound of the formula $8CaO.2SiO_2.Al_2O_3$ was identical with the alite of portland cement clinker.

Summarizing, it may be said that portland cement clinker is a conglomerate of crystals of lime-silica and lime-alumina compounds, compounds of lime, silica and alumina or iron oxide together with solutions and mixed crystals of these compounds which have partially taken up lime to form a solid solution.

Endell in his address at the General Meeting of the Association of German Portland Cement Manufacturers in 1914 (Constitutional Concepts and Sintering of Portland Cement Clinker, Zementverlag, Charlottenburg, 1914) presented a solid model on the basis of the diagram proposed for the ternary system $CaO-SiO_2-Al_2O_3$ by Shepherd and Rankin, which contains the fusion surfaces of the possible combinations of the compounds of this system and he indicated thereon the limits within which the German portland cements appear as shown by their analyses.

Up to that time then there had been investigated and their approximate position in the ternary system determined the possible compounds, crystalline aggregates and solutions within which the portland cements were to be classified on the basis of their chemical composition and mode of preparation. However, these results were supported only by a few measurements obtained in special processes for producing portland cement and thus there was no certainty that the data obtained from the investigation of pure artificial compounds prepared on a small scale corresponded to the well established relationships of actual manufacturing practice. Important as these works were and great though the clarification produced as to the large number of compounds possible in this ternary system, nevertheless they cannot be considered as a final solution of the constitution of portland cement, as most of the data are based chiefly on laboratory experiments which differ considerably from the conditions obtained in large scale portland cement manufacture. In preparing the various compounds they were always obtained from melts. But portland cement is never melted, but only sintered. In many cases temperatures had to be applied in these fusions which do not prevail in portland cement manufacture. This difference between the scientific investigation of the ternary system in question and the technical method of manufacture has been repeatedly pointed out (also by Findell in the address mentioned, in which the literature relating to this point is cited).

Furthermore there is the fact that technical practice due to war conditions and also to technical progress was subjected to important changes and that the material which we today call portland cement has properties considerably different from the portland cement of 10 years ago.

Nacken (Protokoll 1921) at the instance of Dr. Müller, Chairman of the Association of German Portland Cement Manufacturers undertook for the first time exact measurement on the technical calcination process of the raw material mixture for portland cement which serve as the basis for the most recent investigations in this field.

The calcination is carried out in rotary kilns according to the fixed practice of the art of portland cement manufacture; in the kilns the individual phases of the calcination can be quite exactly observed due to their great length. Temperatures in the interior of the kiln were determined the calcination interrupted and samples of the various phases of the process were taken and investigated. Dr. Müller provided an opportunity for this work at the Rüdersdorf plant and arranged for drilling the kiln and determining the temperatures during the run. Nacken thus determined the temperature of the hot gases, especially in the so-called sintering zone as 1430° C., that of the clinker produced as 1370° C., and made temperature measurements in other parts of the kiln, and when the run was interrupted he took numerous samples which he investigated. In this manner it was possible to construct an exact temperature diagram of the calcination process and to compare it with the structure of the products appearing at the various temperatures. The most recent investigations in the field of the constitution of portland cement are based on Nacken's results, those of his pupil, Byckerhoff, who repeating the work of previous investigators again prepared the most important compounds in the ternary system: lime-silica-alumina, investigated them chemically ad petrographically; and on the other hand he also investigated the production process by heating curves, like Nacken; he calcined pure compounds and also technical and synthetic cement raw material in a manner analogous to the technical process, he investigated the individual phases and by comparing them he arrived at the possibility of explaining the technical calcination process.

Dyckerhoff ("Zement," Charlottenburg, 1920, 1, 2, 4, 6, 7, 8, 9, 10) prepared the possible lime silicates, $CaO.SiO_2$, $2CaO.SiO_2$, $3CaO.SiO_2$ and $3CaO.2SiO_2$, determined the relationships of the three modifications of dicalcium silicate and the other lime silicates by heating and cooling curves as well as by optical investigations and studied similarly the calcium aluminates and the compound $8CaO.2SiO_2.Al_2O_3$ discovered by Jänecke. By comparison with the heating curve of a technical powdered raw material he finds that technical portland cement clinker consists of about two-thirds of β-dicalcium silicate which has taken up an appreciable amount of CaO in solid solution, and which by sudden chilling of the so-called residual melt, consisting of tricalcium aluminate and pentatricalcium aluminate in which it is imbedded remains in the unstable form.

Be determined further that tricalcium silicate and the compound $8CaO.2SiO_2.Al_2O_3$ discovered by Jänecke can play no part in portland cement and found the reason for this in the fact that formation temperature necessary for these compounds was not attained in portland cement manufacture, for the reaction of the formation of tricalcium silicate while it does begin at 1350° C. first becomes of practical value between 1600° and 1800° C.

The preparation of the compound $8CaO.2SiO_2.Al_2O_3$ first became possible at 1600-1800° C. a temperature which is never reached in normal portland cement manufacture. Dyckerhoff first extended the theory proposed by Zulkowsky for the formation of lime silicates, especially dicalcium silicate. He showed that β-dicalcium silicate could be obtained in a stable form under certain conditions which he found to be in portland cement manufacture not merely in chilling, but as is explained further on, in the imbedding in the ground mass. At the same time he showed that the β-dicalcium silicate constitutes the most important lime-silica compound at the temperature of portland cement manufacture even below its melting point, which agrees well with the technical manufacturing results.

Finally he found the explanation for the fact in spite of the high lime content of portland cement clinker free lime could be found only in minimal quantities as due to the fact that dicalcium silicate surrounded by the residual melt took up considerable amounts of CaO in solid solution, and he proved that the component of portland cement which determines its chief properties, especialy its hydraulicity is β-dicalcium silicate saturated with lime. Thus he confirmed the significance as indicated by Zulkowsky of dicalcium silicate as the most important constituent of portland cement.

According to Dyckerhoff's investigation the process of calcination of portland cement proceeds as follows: (Al_2O_3 and Fe_2O_3 are always considered by Dyckerhoff as perfectly interchangeable, so that in his publications he always speaks of aluminates which, depending on the composition of the crude charge, may be replaced by the corresponding ferrites).

At 910° C. the CO_2 escapes from the lime. At about 1000° C. monocalcium aluminate is formed and between 1100 and 1200° C. dicalcium silicate.

Dicalcium silicate has three modifications. The γ-modification results from the heating of the proper mixture of lime and silica from 1100° C. on. It is stable at the lower temperatures, but is not hydraulic. With rising temperature the γ-form is gradually transformed into the hydraulic β-form which is unstable at lower temperatures and in the air. The δ-modification which is hydraulic and unstable at lower temperatures is produced from the β-modification from 1420° C. on; it can be prepared pure only in fusions at 2130° C. The reverse process occurs in this manner; on cooling, the δ-form at 1215° C. is suddenly transformed into the β-modification while on slower cooling the latter is reconverted into the γ-form down to 675° C. As this is not hydraulic it can play no important part in portland cement. The β-form which results from the calcination temperatures employed in practise is stable if it takes certain small amounts of material into solution (silica or lime) and is vigorously chilled. According to Dyckerhoff this stability is attained in portland cement manufacture as follows.

After the formation of dicalcium silicate the temperature rises to 1285° C. At this temperature the residual materials consisting of lime aluminates melt and surround the crystals of β-dicalcium silicate. This is the so-called sintering process. With further increase of the temperature to about 1400° C. the β-dicalcium silicate dissolves considerable amounts of CaO from the residual melt. During the following cooling the residual melt solidifies at 1215° C. and prevents the crystals of β-dicalcium silicate imbedded in it and saturated with lime from reverting to the γ-modification which would first occur at 675° C. by resisting by its solidification the pressure which results from the tendency of the β-dicalcium silicate to revert to the γ-modification. Thus the hydraulic form of dicalcium silicate is stabilized even at lower temperatures.

The existence of the compound

$8CaO.2SiO_2.Al_2O_3$ with Jaenecke considers as alite, the chief constituent of the portland cement clinker, and which was contested by practically all cement investigators before the publication of Dyckerhoff's work has been definitely proved by Dyckerhoff to exist. On the basis of the above picture of the calcination process he considers the production of this compound during normal portland cement manufacture as impossible and above all it is not identical with alite. Jaenecke ("Zement," Charlottenburg 1925, No. 2) opposes this conclusion and while he admits the high temperature of formation for $8CaO.2SiO_2.Al_2O_3$ he sticks to his conclusion that this compound is the alite of cement and bases this conclusion on the comparison of the optical properties. Here we have arrived at the boundary of the present status of investigation.

Cement investigation has had to travel a difficult road from Le Chatelier's time to the present, and the clarification of the complicated process of technical cement manufacture would not have been possible to the extent to which it has already occurred if the scientific investigational technique had not employed petrographic, thermochemical and optical methods of investigation.

We may call attention to Nacken's latest publication ("Zement," Charlottenburg, 1925, No. 19 and 20) in which he describes the application of x-rays to cement research and which should open new perspectives for the further clearing up of the cement problem.

Manufacturing Technology

Cement manufacture consists principally of crushing, grinding and calcining. The mechanical improvement of crushing methods, especially of hard materials, has made important progress. Shortly before the War the most varied types of stone crushers were highly developed, especially in America. A new type of coarse crusher is the hammer mill.

The grinding of the three principal raw materials of portland cement manufacture, lime, cement clinker and coal was formerly done in ball and tube mills. In the ball mill grinding is done by the dropping of steel balls onto a rotating cylinder lined with steel plates; in the tube mill by the sliding of flints or specially shaped grinding bodies in a rotating cylinder which is lined either with a quartzite (silex) lining or is armored with steel plates. Screens were installed between the ball and tube mills. In the last years before the War a combination of ball and tube mills appeared, characterized by the fact that both grinding operations, namely coarser grinding in the ball mill and fine grinding in the tube mill, were united in a single apparatus. This is the so-called compound mill which consists of a coarse compartment with steel balls and a fine compartment with specially designed steel forms. More recently this mill has been perfected by the construction of multiple compartment mills which are better adapted to the properties of the individual materials handled and are composed of a preliminary compartment with steel balls and two fine grinding compartments with flints and steel grinding bodies. It is possible with this apparatus without screening and without bothersome transport to obtain extraordinarily fine grinding of material. An average output of 2200 lbs. of finest cement flour leaving less than 10% on a 175 mesh screen can be obtained with an average power consumption of 300 KWh. It is characteristic of this grinding system that the pulverization is very thorough and the use of a 175 mesh screen does not give a complete picture of the output of these mills.

The fineness of the individual materials plays an important part in the manufacture of portland cement. The more heterogeneous the raw materials the more thoroughly must they be mixed with each other. The finest grinding possible is necessary for this. In order to obtain this result there has been a partial change to wet grinding of hard raw material and the resultant slime is pneumatically or mechanically mixed in large containers and then pumped into the rotary kilns. It seems obvious that this process has certain defects as the added water amounting to 30 or 40% of the raw material must be handled by the kiln and evaporated too. A corresponding degree of fine grinding of the hard raw materials in the dry way could not be obtained with sufficient economy by the ordinary ball and tube mills.

The invention of compound mills and air separation indicates the corresponding advance in the field of dry grinding which has been completed by the introduction of multiple mills.

The system of air separation renders possible a complete fine grinding even in ball mills by freeing the product of the ball mill of its finer components and returning the coarser fraction for regrinding. The result has been the construction of extraordinarily large ball mills in which a satisfactory fineness is obtained by rerunning the coarser fractions from the separators. Air separation makes possible a very complete classification of the ground product and leaves as small as desired a residue on the 175 mesh screen. However, in this combination system of ball mill and air separator in order to obtain a content of very small fines equal to that from the multi-stage mills a much smaller residue on the 175 mesh screen would have to be specified than for the product from the multi-stage mills.

The 175 mesh screen no longer gives satisfactory information as to the effectiveness of a grinding system and the true content of high grade fines. The use of 250 mesh screens has been introduced but even this is not good enough. The air separator constructed by Gary (Prof. d. Ver. dtsch. Portlandzement fabrikanten 1907) or similar apparatus is better.

The same holds true for the grinding of the clinker as for the dry grinding of the hard raw materials. It may be said of coal pulverization, which plays an important role in rotary kiln practise, that the coal is ground down so that only 10% remains on a 175 mesh screen; we may refer to the literature on pulverized coal combustion which plays so important a part in modern boiler practise and the knowledge of which has become general in present-day technology.

But it must be emphasized that it was the cement industry which gathered important data in this field at a time when other industries were not yet thinking of pulverized coal combustion.

For a time certain types of mills invented in the United States and partially adopted in Germany competed with the above described grinding systems: cannon mills (Griffin and Giant mills), roll mills (Kent and Ring mills) and the so-called Fuller mills, a mill system with a vertical travel in which relatively large steel balls were moved against a grinding ring by cast steel impellers. The grinding effect of some of these mills is very important with respect to the content of high-grade fines. They are, however, economical only for materials of medium hardness, and in general, if they are used for very fine grinding they are subject to heavy wear of some of their parts. They are also used in combination with air separators.

Grinding in modern mills produces a very great movement of material and consequently imposes severe specifications on the construction of equipment. Most installations of ball and tube mills employ gear drive. An exception from this point of view is presented by the construction of a ball mill of very large dimensions, the so-called "hard-mill," in which the mill cylinder is driven on guides by specially designed transmission rollers which are in turn driectly driven. The extensive use of gear reducers, roller and ball bearings in milling practice has introduced improvements in the design and in power requirements so that heavy and slowly operating mills are being directly driven by high speed motors with a saving in power. It may be noted that similar driving systems are being introduced into the cement industry to operate very heavy rotary kilns and dryers.

The most important piece of equipment in a cement plant is the kiln. As the cement industry has developed from the lime burning industry, formerly the cement industry used kilns similar to lime-burners and there are still individual plants in which the clinker is calcined in annular kilns. But in general there was a rapid transition to shaft furnaces of which a great number of types has existed in the cement industry. Up to recent times only one type of furnace construction has maintained its position, the so-called Schneider furnace the operation of which has been made completely automatic by special charging and discharging equipment. This automatic shaft furnace was widely adopted, especially in Germany, during the war. The reason for this lay in the scarcity of coal and the lower consumption of coal in this type of furnace. The manufacturing process in the automatic shaft furnace is as follows: The dried and finely ground charge is ordinarily elevated to the charging top, mixed with proper amount of coke fines, the mixture pressed into bricks by automatic brick presses and fed into the furnace by a special delivery device. The furnace is completely filled with the charge. At the bottom of the furnace is a slowly moving discharge grate which discharges the finished product. Charging and discharging are conducted with special devices preventing access of air. The draft is artificial and can be regulated exactly, the charge sinks slowly into the preheated zone in which moisture is driven out and then into the calcination zone, from there to the sintering zone and finally into the cooling zone. The formation of too large sintered lumps of clinker which was the disadvantage of the shaft furnace with hand operation is largely prevented by the automatic operation when carefully conducted. The coal consumption varies with the composition of the charge and the calorific value of the coke at from 12-18% of the clinker produced. Attempts to conduct the combustion with pulverized coal have not proved definitely impossible. The scarcity of coal during the War and the availability of coke breeze as compared to coal gave widespread popularity to this furnace because of its low fuel requirements. 220 pounds of clinker required 90,000 calories for sintering.

The most common system in large modern plants is the rotary kiln. This is a large slowly rotating wrought-iron tube, horizontal with a small inclination, lined with firebrick; its length is 40 to 60 meters and its diameter 2 to 3½ meters, depending on the output desired. Here also there are various systems. There are rotary kilns with extended sintering zones, extended calcining zones, with underbuilt coolers and cooling equipment built around the exit from the kiln. Into the upper end of the kiln the heavy slime or the finely ground, generally somewhat moistened charge, at the other end the pulverized coal is introduced with air pressure; in the most efficient type the air is taken from the clinker cooler and thus part of the sensible heat of the clinker is used to preheat the air. The material fills the kiln only to a small extent. Extremely large volumes of gas pass through it. The firing is done with finely pulverized bituminous or brown coal; in individual cases, with crude oil or natural gas. The fuel consumption is higher than with shaft furnaces and amounts to 150,000-200,000 calories for 220 pounds of clinker which is due to the heating of large volumes of gas and heat radiation. However, relatively low grade coals can be used.

The contact of the kiln charge with the flame is more intensive by far than in the shaft furnace and also easier to effect. The introduction of charge is always subject to regulation, coal and air supply can be regulated by the pulverized coal feed, the rotary speed is adjustable and the course of the burning is easy to observe, thus making possible a close adjustment of the sintering process and a uniform quality of product. The coal requirements are heavy, producing high exhaust gas temperatures. Combustion is carried out so that the exhaust gases contain no oxygen, no carbon monoxide, but only carbon dioxide, hydrogen and nitrogen. In the wet slime process in which the raw materials are introduced with 35% of water, the exit gas temperature is 400-600° C., in the dry process 700-1000° C. according to the length and operating rate of the kiln. These exhaust gases contain extremely large amounts of heat which are wasted partially or completely. In the dry process the waste gases are ordinarily used to dry materials for grinding. But even here the utilization of this heat is not economical. In properly functioning kiln operation it is possible to obtain as many heat units per carload of finished clinker as would be necessary to supply all the power required to manufacture a carload of clinker, that is to say, if the waste heat were utilized under boilers all the power requirements of the plant would be met. 270,000 lbs. of cement require between 900 and 1100 KWH.

The problem of waste heat utilization was studied in Germany before the war, and especially south German cement factories have equipped large rotary kiln installations for the recovery of waste heat. The original fear that the dust carried over by the gases from the kiln would corrode the boilers has not proved to be serious, as it is possible easily to remove this dust by suitably constructed equipment. On the other hand, at first data were missing as to necessary relationships of gas volumes and boiler sizes.

The gas volume produced by the burning process is very large which necessitates very large boilers to utilize the waste heat. An important feature is the production of a tight connection with the brickwork and a strong and serviceable insulation of the furnace and the whole brickwork. Practical data are still missing for this is Europe, as during the war only the immediate necessities could be considered, and the expensive investigation necessary could not be undertaken. On the other hand extensive progress in this field has been made in the United States and a large part of the very highly productive American cement industry uses the waste heat with success. Although the reports reaching Europe seem very optimistic, they are not complete enough to furnish a complete picture of the coal consumption in the kiln. It is also obvious that the capital costs are very high because of the size of the boilers and the difficulty of insulation. There is the additional difficulty that in existing plants the installation of the boilers behind or near the rotary kilns would involve considerable reconstruction, which is not lightly undertaken by the factory management and it is questionable whether in every case the interest and amortization of the invested capital is met by the savings effected. Plants with cheap water power are excluded to begin with as well as those whose coal costs are very low. In view of the present world coal crisis the question of the profitableness of an investment which apparently has such an attractive result should be most carefully considered. In general it may be considered that the American achievements will prove successful in Europe, too, and thus the rotary kiln will attain a further advantage over all other systems.

For the sake of completeness we may note that advances have been made in the construction of packing machinery and above all in the field of electrical dust removal.

Quality

It is required of a good portland cement that after admixture with water it should begin to set within a certain time (about 3-4 hours), the setting process should go to apparent completion within a certain time (3-4 hours), that during and after the setting no increase in volume should occur and no excessive shrinkage appear, and that after several days a satisfactory strength should be developed. As to the setting time and constancy of volume these are practically always met, in spite of seven specifications, by all the portland cements of standard manufacture. As to the tendency to harden and the strength tests, these were formerly specified so low in practically all countries that they were greatly exceeded by almost every portland cement. The requirements for the use of portland cement in general stated that structures made of it could be removed from forms and put into use after 4-6 weeks. This specification has long been unessential with respect to foundation and rammed concrete, and even in the case of reinforced concrete construction, the loading requirements for which are much stricter than for ordinary formed concrete, these requirements as to time before removal of forms have been easily improved on. The usual standards for portland cement until recently specified that mixed with standard sand in 1:3 ratio, after 28 days' setting, depending on the conditions, a compression strength of 200-3000 kg/qcm (2750-4152 lbs. per sq. in.) should be obtained. An ordinary portland cement on the average reaches this figure after 7-14 days' setting and after 28 days ordinarily reaches 5500-8250 pounds per sq. inch.

In the years 1915-16 Spindel (Oesterr. Worchenschr. f.d. oeffentl. Baudienst 1925 p. 41, 1916, p. 22, 23) reported on very interesting tests in which he puts reinforced concrete structures in use after two days. The portland cement was of standard composition and very high quality. This high quality portland cement is now produced by a number of plants. They are rotary kiln cements, the chemical composition of which is within the ordinary limits, but is very uniform, not only as to lime content, but as to all other components, in which the ratio of lime to silica on one hand and to alumina and iron oxide on the other is very exactly maintained, and the strengths specified in the standards after 28 days are reached or exceeded after 2 or 3 days. There are quite a number of methods for the production of high grade cements, which attempt to reach the same goal by special additions to the raw material or to the finished cement. All these cements are generally very carefully prepared and relatively finely ground. In their manufacture the process is controlled and regulated with all the aids available to modern science. In most undertakings the process represents a special product of an ordinary plant, but in some the manufacture has been developed to regular large-scale operation. Relative to the applications of these cements, extensive investigations have been made by Gessner-Nowak (J. Melan—70th Birthday—F. Deuticke, Leipzig), Gehler (Zement, 1924, No. 16-19), Rueth (Beton u. Eisen 1924, 6, 8, 1916) and Otzen (Bauingenieur, 1925, p. 3). These investigations have led to the conclusion that structures built of this so-called high grade cement can have the time in forms reduced to five and as a maximum 14 days. The importance of such an advance in construction can hardly be estimated. The above-mentioned scientific investigations have shown that for standard mixture ratios concrete mixtures using such cements can meet specifications determined not by the strength of the cement but by the elastic limits of the iron reinforcements. The result of this is that tests have been undertaken (Gessner-Nowak, Beton u. Eisen, 1924, page 4) with higher grade reinforcements which have led to very excellent results.

Excellent results in highway and railroad construction (which involve interruption of traffic) have been obtained with high grade portland cements and the disturbance to traffic has been greatly cut down. The roadway of a railroad bridge was put into service eight days after laying the concrete (Publications of the Tschecko-slovak Ministry of Labor, 1925, No. 1). Urgent factory construction could be completed with great speed, as for instance a four-story factory building within five weeks from the starting of the foundation to the completion of the roof. The savings in forms are very important. The use of steel inserts instead of ordinary ferro-concrete produces great savings in the height of structures and in the wall-work to be filled on account of the smaller area to be covered. But most important are the savings affected by the smaller period of non-use, as compared to the earlier methods. In spite of the somewhat higher cost of high grade portland cement, the construction costs are somewhat lower.

Portland cement is beginning to put out of business a number of materials hitherto used, and is, above all, offering strong competition to iron, and is entering into uses which formerly were not considered at all. As an example it has been applied to road construction in which it seems destined to have a great future. The requirements of roads to meet automobile traffic are unusual. Even the best laid down roads suffer heavily and after a short time need to be repaired. In the land of automobile development, the United States, the step has been taken of giving roads a ferro-concrete armor: the entire road is covered with reinforced concrete and is thus given a smoothness and a resistance to wear such as can be obtained with no other material. High grade portland cement which apparently will soon be quite generally used will play a distinguished part in road building enterprises as it renders possible rapid construction in a remarkable manner.

German cement manufacturers in the past year have thoroughly studied American methods of cement manufacture as well as the applications of cement and together with many other interesting observations have come back to Europe with the conviction that ferro-concrete roads will be the automobile highways of the future. At their request a special commission for the study of highway construction has been formed and a number of test roads have been built in which the American advances have been used and extended. It seems, therefore, to be beyond question that portland cement will find an even broader use than at present and that those who have provided not only for cheaper production but also above all for improvement in quality by means of scientific methods will reap the harvest of their labors in a short time.

A special stimulus to improve the quality of standard portland cement and to provide a high degree of strength even after a few days has been provided by a French patent. Bied (Bull. Ste.d'Encour. pour l'Ind. Nationale, Jan. 1923) has been the first to prepare an aluminate cement on a manufacturing scale.

Schott (Dissertation previously quoted), when he tested the individual synthetically prepared lime-silica and lime-alumina compounds for strength, pointed out the high strength figures for lime-aluminates. He finds for monocalcium aluminate mixed with normal sand in the ratio of 1:3 a tensile strength after 28 days of 730 pounds per square inch, a figure which even today can hardly be obtained by a good portland cement. The so-called aluminate cements have a totally different composition than portland cement. They contain approximately

	Aluminate Cement	Portland Cement
SiO_2	5-15%	20-22%
Al_2O_3	35-45%	10-11% (Al_2O_3 + Fe_2O_3)
Fe_2O_3	10-15%	
CaO	35-40%	64-67%

Furthermore they are prepared from other raw materials than portland cement. Up to the present no raw material sufficiently high in alumina for the preparation of these cements has been found other than bauxite which is quite suitable for the production of silicate cements. The attempts to use dust from roasting, bog iron ore, etc. instead of bauxite have not been tried on a large scale. Aluminate cement is not sintered, but fused, For its manufacture an electric furnace or a water-jacketed furnace is used. Aluminate cements are characterized by extremely high initial strength even after one day's setting and very great resistance to chemical influences. It has been used in France with success for large-scale construction. It will hardly play an important role for the rest of Europe, except Jugoslavia where bauxites are found, so long as the present process remains necessary and expensive bauxite burdened with heavy freight charges is used as raw material. True competition from it against portland cement will appear only where the structure under consideration requires great resistance to chemical action, or, for instance, in shaft construction by the freezing process as it is possible to have it set at temperatures below the freezing point. It liberates heat during the setting process to such an extent that the temperature of the cement (especially of the slacking water) is raised to the point that setting occurs. For all other purposes, the cost of manufacture is too high at present, and for ordinary structures such short periods in the forms are now required by high grade portland cement that the latter can hardly be utilized in practice less effectively than aluminate cements. Even for concreting at low temperatures and during the prevalence of frosts during the period in the forms, aluminate cements enter into consideration only if an extremely short time is available, for, as tests have shown, (Gessner, Ingenieurzeitschrift, Teplitz 1924, Beton u. Eisen, 1925 No. 10) high grade portland cement shows sufficient hardening tendency at low temperatures to be able to overcome frosts during the period in the forms without appreciably increasing the time for construction. Naturally he excludes temperatures below freezing at which aluminate cements because of their strong heating effect during the setting process can still be used.

Cement Association Changes

The Portland Cement Association announces the opening of an office at 939 "O" Street, Lincoln, Nebraska, under the direction of Donald D. Price, district engineer.

Mr. Price has been connected with the Portland Cement Association for the past year and a half as field engineer in Nebraska. Since his graduation from the civil engineering department of the University of Nebraska, he has filled a number of important engineering positions in the state, as well as having engaged in consulting engineering practice. R. M. Simrall has been named district engineer at Kansas City in charge of association work in western Missouri and Kansas. Mr. Simrall was formerly a field engineer for the association in Kansas and previous to that was engaged in engineering work in Oklahoma and Missouri.

The association has named Forest Kaufman as manager of its Southwestern offices in the Gloyd building, Kansas City, Missouri. The district offices of this section are Kansas City, Oklahoma City, Dallas, Lincoln and Denver. These offices have charge of the association's work in Kansas, Nebraska, Oklahoma, Texas, Wyoming, New Mexico and western Missouri. Mr. Kaufman came to the association in 1916, serving first as field engineer in Illinois. He later was made district engineer at Kansas City and then manager in charge of the Kansas City and Oklahoma City offices.

Federal Gravel Co., Saginaw, Mich. Capital $210,000.

James Sand and Gravel Co., Paducah, Ky. Capital $75,000. Incorporators: J. E. James, H. L. Richardson and John K. Ferguson.

Producers Core Sand Corporation, Michigan City, Ind. Capital stock $10,000. Operate sand pits and sale of sand. Directors: E. L. Spraker, William H. Westphal, Carl Zesse, Carter H. Manny, William B. Manny.

Producing as Neighbors in Oregon

By E. D. Roberts

UMATILLA County, in the northeastern part of the state of Washington where the Umatilla river empties into the Columbia, has a reputation extending all over that section of the county for the clean, sharp, sand and gravel it produces, suitable for all building purposes. An especially rich deposit is found about a mile and a half southeast of the town of Umatilla alongside the river of that name and two miles above the junction of the streams.

This deposit is worked by two neighboring competing companies which operate along somewhat similar lines. Both ship by the Union Pacific Railroad which skirts their plants and have an outlet for their trucks over the old Oregon Trail which passes near by. Both companies have an arrangement whereby the Union Pacific takes their oversize product at cost of plant handling for use in mass concrete and for making shoulders for hand car turnouts, block signal bases, and other special heavy concrete work along the right-of-way.

Jones-Scott Company

The Jones-Scott Company, which maintains its headquarters in Walla Walla, operates an efficient plant and dry pit a half mile east of the Umatilla River; the main line of the Union Pacific goes between their operation and the river. The deposit

Loading at Umatilla Plant

has an over-burden of sandy soil varying in depth from six inches to six feet, which is scraped to one side leaving a clean bank of gravel of uniform size and of excellent quality for concrete, building and road work. Previous operations have developed the deposit extensively and have provided a working face at the present which is 85 feet high.

During the early part of this year this plant was modernized. Two Fairbanks Morse Y type semi-diesel engines were installed replacing the steam boilers and engines. Permanent housing was placed over all

Jones-Scott Pit Showing Bunker Trap and Engine House

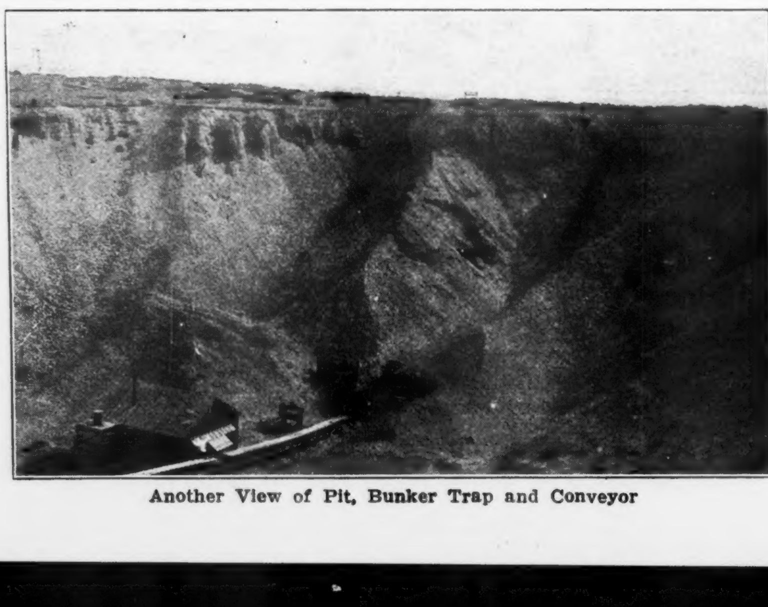
Umatilla Power Plant and Hoist

equipment which was placed upon concrete foundations, and the plant now presents a pleasing appearance.

A Bagley one yard scraper, operating on a 300 foot line, excavates the material and discharges it onto a grizzly which rejects any rocks that will not pass the crusher. It is seldom that such rocks are encountered so that the material passes through the primary grizzly into a hopper holding five cubic yards. A 20-inch conveyor belt operates under this hopper and draws off the material at a uniform rate transporting it horizontally 300 feet and at the same time elevating it 50 feet. It discharges the sand and gravel onto an inclined grizzly. The sand and gravel under 1½ inches in size falls into a chute which guides it to an inclined Link Belt bucket elevator, while that above 1½ inches is chuted by the grizzly directly into a number 4 Austin gyratory crusher set to 2½ inches and less. The discharge from the crusher joins the material passing through the grizzly at the foot of the Link Belt elevator and is raised with it a vertical distance of 50 feet in two stages.

Discharged into a revolving screen by the bucket elevator, it is separated into sizes from sand to ¼ inch, ½ to 1½ inch, 1½ to 2½ inch, and oversize. These sizes fall directly into their respective bins beneath the screen. Each bin holds 40 cubic yards and has spouts to load railroad cars or automobile trucks. A large percentage of the output is shipped by rail and is loaded directly into cars spotted on the spur alongside the bunkers. A heavy traffic auto truck road constructed to the bunkers from the Oregon Trail highway allows them to make shipments by this means.

The Bagley scraper is operated by a Tacoma hoist directly connected to a Fairbanks Morse 40 h.p. Y type semi-diesel engine by a clutch that works equally on the engine and hoist shafts. The remainder of the plant machinery, consisting of the conveyor belt, Austin crusher, Link Belt elevator, and the sizing screen, is operated by a 60 h.p. Fairbanks Morse semi-diesel gas engine of the same type. Both engines are set on permanent concrete foundations and housed by suitable frame buildings. The conveyor belt is also covered over and supported on a frame structure rest-



Another View of Pit, Bunker Trap and Conveyor ing on concrete foundations. Both engines are equipped to start by means of compressed air.

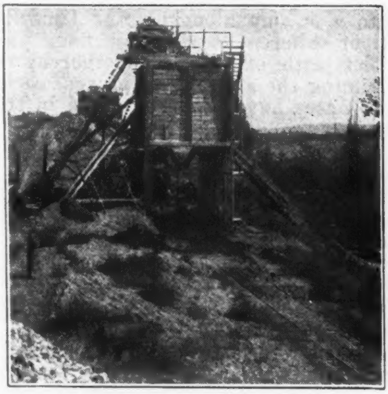
Two hundred cubic yards of sand, gravel and oversize material are the average output of this plant in an eight hour shift. The pit and plant crew is made up of three men whose duties are as follows: One man operates the 40 h.p. engine, hoist and scraper excavating the material; another man tends the crusher; and the third man tends the 60 h.p. engine and supervises the plant.

Umatilla Sand and Gravel Co.

When J. K. Shotland of Hermiston, Oregon, acquired control of the Umatilla Sand and Gravel Company in March, 1925, by purchasing the holdings of several of the original stockholders living in Pendleton, he continued to operate under its old name, partly on account of the prestige this company had gained and partly due to Umatilla county's reputation for good sand and gravel.

The deposit of this company is located on the east bank of the Umatilla River. Three acres have been worked down to the water level of the river, leaving five acres of sand and gravel to handle.

No attempt is made to remove the overburden which is excavated with the sand and gravel by a one yard Bagley scraper, operating on a 300 foot line to be washed out during the screening process. The Bagley discharges its load onto a grizzly that guards against oversize. From this grizzly it falls onto an inclined grizzly which allows material under 1½ inch in size to fall through into the boot pit of a bucket elevator, while the



Layout of Umatilla Plant

oversize slides down the bars and into the jaws of a number 2 Aurora crusher set at 1½ inches. The discharge from the crusher falls into the same boot pit and is picked up by the same bucket elevator which handled the smaller material.

The bucket elevator is made up of Link Belt buckets attached to a 16 inch 8 ply belt. It discharges the mixed material into a 16 foot revolving screen equipped with a 72 inch sand jacket around the feed end. The main screen has 1½ inch circular holes and the sand jacket ¼ inch holes which gives three grades of material sand, ¼ to 1½ inch and over 1½ inch. Water is sprayed into the mixture as it enters the screen and throughout the full length of the screen by a 3½ inch sieved pipe. This water passes through with the sand and is removed from the sand by a sand jacket. The dirty water is piped

Jones-Scott Crushing and Screening Plant, New Engine House at Right into a swamp alongside the Umatilla River where the silt and finer particles settle off, filling and thereby reclaiming the swamp. At present about two acres have been reclaimed in this way.

The sand, ½ to 1½ inch, and the oversized materials all fall into their respective bins directly underneath the screen. The bunker, having a capacity of about 200 yards is divided into three compartments, one holding 60 yards for sand, and two holding 70 yards each for the two other sizes produced by the plant.

Most of the shipments are made by rail, and consequently the bunkers were built over a spur track allowing cars to be loaded by spouts in the bin bottoms. The spur track has been filled with the oversize material up to the top of the rails and packed so that it makes a good road for auto trucks which use this means for loading when shipments are made by truck.

Two hundred cubic yards of material are the average output of the plant per working day for most of the year. The winters are mild and freezing weather of short duration.

The power for operation of the plant is generated in a way that shows the many uses in which portable power units can be used. The drag line, and bucket line, screen and crusher are operated by a 45 h.p. Minneapolis steam tractor. The hoist operating the bucket line is directly connected to the tractor by a shaft while the power for operation of the crusher, bucket elevator and screen is taken off the tractor pulley by belts.

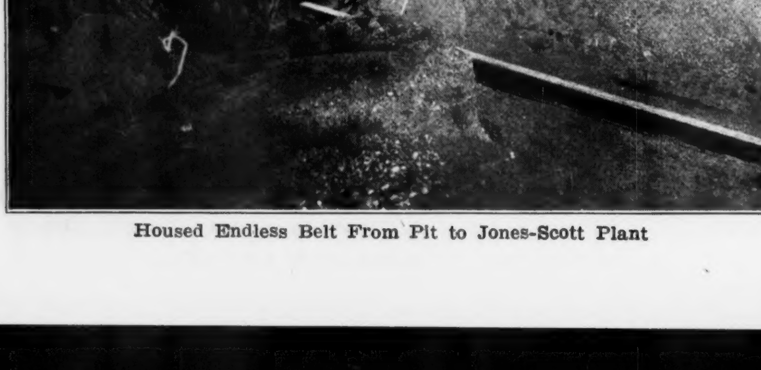
Water for washing the sand and gravel as well as for supplying the steam engine is furnished by a 4 inch centrifugal pump located at the river. A Fordson driving a line shaft by a belt which in turn drives the pump by another belt at 1,500 r.p.m. furnishes the power for the pumping operations.

As stated before most of the output is shipped by railroad but in case shipments are made by auto truck they use the spur track for a roadway to the bunkers. Consequently trucks cannot load while cars are spotted on the tracks. As truck shipments are small in comparison to those made by car, this is not such a serious handicap as it might seem.

American Gypsum Company Re-Elect Officers

J. H. McGrady, Pittsburgh, has been re-elected president of the American Gypsum Company; F. J. Griswold, Port Clinton, vice-president and general manager; J. B. Davis, Cleveland, secretary and treasurer. The other members of the board of directors are: P. K. Tadsen, Port Clinton; Charles Miller, Cleveland; Ed. McCrady, Braddock, Pennsylvania; and Harry Beens, Pittsburgh.

The Buckhill Washed Sand and Gravel Co., Canton, Ohio. Capital $50,000; Herbert C. Taylor, W. G. Ashbrook, Helen M. Light, E. H. Benson and William T. Kirk, incorporators.



Housed Endless Belt From Pit to Jones-Scott Plant

Compressed Air and Air Compressors

By C. H. Sonntag.

Part IV

Compressor Valves

AS far as consistent, the mechanical construction of compressors has always kept pace with the best in steam engine practice, but until the last few years the speed, and so the possible output, from a given cylinder has been limited by the ability to get the air into and out of the cylinder. This limitation lay in the inertia of the valves then in use, which were of two kinds, the poppet and the Corliss. The former depended largely on spring pressure for their motion in one direction, and that of the atmosphere or the air in the cylinder for the other direction. The valves were heavy and required an appreciable force to get them started, and as they had only one opening, high lift was necessary to get capacity. To get them seated at the proper time considerable spring tension was required, and this in connection with the high lift resulted in destructive pounding of the seats as well as much noise, both of which became worse as the size of the valve and the speed of the compressor increased.

The difficulty of getting poppet suction valves to open and close at the proper time brought about the use of the Corliss valve on large machines. They were positively operated, since closing by dash-pot has been found in steam engine practice to be unreliable above 125 r.p.m. Various link-motions have been developed for securing quick opening and quick closing of the Corliss valve without releasing it, but the maintenance on them is high and the speed is limited to about 200 r.p.m. It is true too that when the seat of such a valve becomes scored, as occasionally happens, it is usually necessary to rebore the seat and fit a new valve.

All of these things have been done away with and the whole matter of air compression has been put on a higher plane of efficiency and service by the invention of the plate valve. It seems to have originated in Germany, but the idea has been so developed that present-day valves bear little resemblance to those first brought out. They are now in practically universal use, and a group of the designs of prominent American builders is shown on an accompanying page.

Plate valves have done away with the tedious grinding jobs that were necessary every time a poppet valve became leaky or was replaced. They have permitted a considerable increase in speed, which is translated into more capacity for a given size or a smaller machine for the same capacity, with less floor space, smaller foundation and cheaper direct-connected motor if used. The modern light-weight, high-speed portable compressor would be almost out of the question were it not for plate valves, for some of them run at 800 r.p.m.

It will be noted that in all the designs shown the valve, its seat and its retainer constitute a unit, quickly removable and replaceable with no tool but a wrench. Breakage is confined to light, thin pieces of steel that can be replaced by new ones at the cost of a few cents with no grinding or machine work. Another favorable point is that each plate as it lifts offers two openings for the passage of air, so that the height of lift for a stated capacity is much less than with the poppet valve. The light weight of the plates and their low lift make springs almost unnecessary, and they will open and close when they should, and seat with negligible shock or hammer-blow. A valve unit may be made up of two or three independent plates, each covering its own opening. If all the plates are held down by springs of equal tension the larger may be the only one to lift at light loads, the others coming into action as the amount of air to be passed increases.

In figure 10 (l) the valve is a single ring seating on a single port with flush surface, and guided on its inside edge by projections on the seat. Slight initial pressure is given by the annular spring bent to the shape shown, and the lift is limited by guard plate against which the spring reacts.

A type quite different from the preceding, but largely used, may be studied in figure 13 (o). The essential part is a group of separate rectangular strips of thin steel confined and guided over separate ports. Each works in a separate recess in the cover-plate, so shaped that the lift is practically zero at each end of the

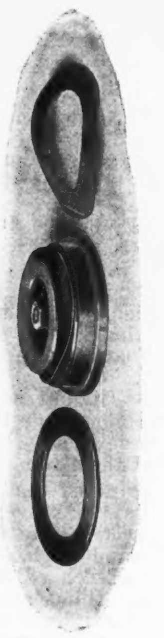


Figure 10

Figure 13

strip, but allowing it to bow upward in the middle for some distance. The strips are therefore under slight flexure when the valve is open. It is claimed that the impact on closing is very slight, since the ends of the valve are practically in contact with the seat at all times. No auxiliary springs are used, the tendency of the strips to assume their original form being depended upon to hold them close to their seats when no pressure is above them. A complete valve may contain from one to five or more strips according to the capacity desired.

There are a number of other designs of light-weight valves on the market and used by reputable builders, but the essential features have been covered in the foregoing discussion.

Belt Drive

This is the simplest way of supplying power to a compressor, and a machine for belt drive will cost much less than one which has any sort of power source built into it. Most of those so far illustrated are of this class. Energy may be taken from a separate gas, steam or oil engine or waterwheel used for this one purpose, from a separate electric motor or from a lineshaft transmitting power for other purposes as well. In the latter case operation of the compressor will depend on that of the rest of the mill unless some sort of clutch or cut-off coupling is provided. The arrangement is not very flexible, and should be used only as a last resort.

If a separate steam engine must be purchased to run the compressor it would be far better to buy a combined unit such as will presently be described, as the initial investment will be less, the cost and upkeep of the belt will be avoided, less floor space will be required, and a self-contained unit will be had, aside from the fact that the drive will be more efficient and more air will be obtained per pound of steam.

One method of belting has found considerable favor. It is known as the short belt drive, and will be taken up in treating of motors as power sources.

Direct Steam Drive

A compressor embodying this principle is really a combination steam engine and compressor, having a number of the parts of both machines in common. The simplest is the straight line one stage air type with a simple

(l) Sullivan Machinery Co., Chicago, Ill.
(o) Worthington Pump & Machinery Corp., New York City.

slide valve steam cylinder, such as is shown in figure 14 (p). The steam cylinder is always placed nearest to the shaft, probably because it requires less attention than the air end. It is likely that the majority of the small compressors that are not motor-driven fall in this class. The steam cylinder may have a common slide valve, a balanced slide valve, a piston valve or a Meyer riding cut-off. Corliss valves were at one time extensively used on the steam cylinders of the better class of machines in the larger sizes, but the speed limitations of that valve motion have militated against its continued use since the advent of the plate air valve. Control on all except the Corliss-equipped machines is by a combination speed and pressure regulator that will be described later, operating by throttling the steam. The Meyer valve is a valuable feature, for it allows the point of cut-off to be varied to suit the load, and although the adjustment is by hand a somewhat better steam rate may be had by its use.

Frequently, and especially in the larger sizes, some more efficient drive than the simple slide valve steam cylinder or its modifications is desired, and it may be had by compounding or by adopting the uniflow principle.

Some years ago compressors having the steam cylinders arranged tandem-compound were built, but because of the length of the machines and the difficulty of getting at some of the

(p) Ingersoll-Rand Drill Co., New York.

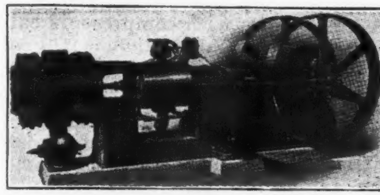


Figure 14

parts, few of these are seen today, and cross-compounding is now standard. In a compressor n which steam compounding is resorted to it is worth while to carry the quest for economy one step farther, and so machines of this class commonly have two-stage air cylinders.

High steam economy may also be obtained thorugh the use of uniflow cylinders. This type of engine was described some time ago in the Pit and Quarry and will not be taken up in detail here, further than to say that the simple uniflow engine is about as low in steam consumption per horsepower developed as the compound engine of older design. When used in a duplex compressor the steam cylinders are alike and no receiver between them is needed. It is likely that as the uniflow engine becomes better known and understood its use will increase.

The economy of all steam-driven compressors can be improved by running them condensing, but this is a matter of ordinary steam engine prac-

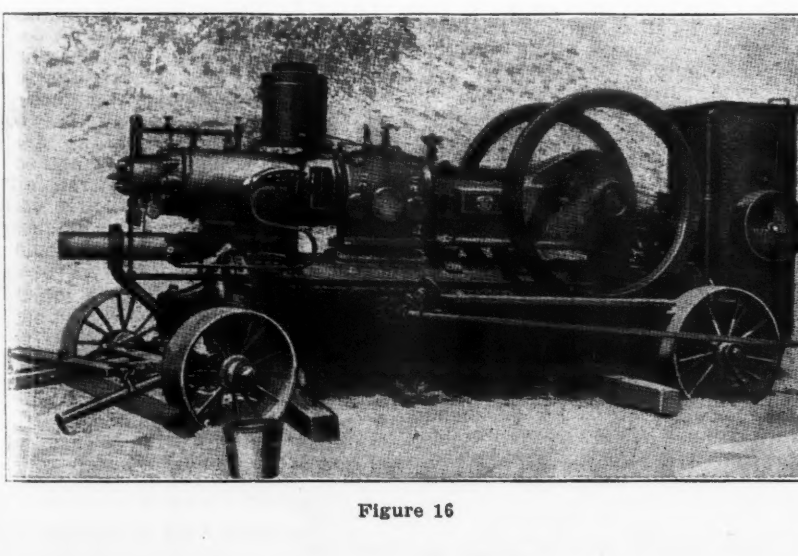


Figure 16

tice, and its use with compressors calls for no special treatment.

Internal Combustion Engine Drive

Gasoline engines for compressor drives are limited to the smaller sizes, and for permanent connection are mostly found on portable machines such as the one previously shown in figure 8. Of course where a suitable separate engine with pulley and a belted compressor are available, any good mechanic can make the one drive the other. Tractor drive is one instance of this.

Fuel oil engine drives designed as integral parts of compressors are usually of the semi-Diesel or hot-bulb type, of which the ignition and combustion details have already been taken up in this magazine (r). These engines use cheap fuel oil and are sufficiently simple and easily handled to be suitable for many temporary jobs. An oil engine air compressor in such service may be seen in figure 16 (s). This particular machine was used to furnish air for rock excavation in road work, and was moved from one location to another on its own wheels. It will be seen that the engine-compressor combination is mounted on top of a heavy tank serving as receiver as well as forming the back-bone of the outfit. At one end is the radiator which cools the jacket water from both cylinders. The tank-mounted machine shown is made in capacities of 144 and 212 cubic feet per minute. It may also be mounted on skids with radiator but without tank, for semi-portable use. When intended for permanent location on a foundation it is furnished in sizes up to 658 cubic feet per minute.

In some parts of the country oil may be cheaper than coal as fuel. This is apt to be the case in the southwest and west, and high-class permanent installations such as are found at the larger metal mines and quarries may find it advisable to use full-Diesel engines to generate power. Such engines can be direct-connected to any of the power-driven compressors that have one end of the shaft accessible. Typical ones of this class are the single-stage, the tandem compound, and the angle compound which were illustrated in the March 15 issue. A plant using Diesel engines will doubtless wish to use two-stage compression unless low pressure air for furnace blowing, or other special service is wanted.

(r) Pit & Quarry, Dec. 1, 1925, p. 79.
(s) Chicago Pneumatic Tool Co., Chicago, Ill.

The Diesel engine may be belted to any of the belt-driven compressors, but direct coupling, when it can be arranged, will make a more compact lay-out and save the first cost and upkeep of the belt. Belting may, however, make available a compressor already on hand or obtainable at a low price.

Motor Drive

Motors may either drive compressors by belt, be direct-coupled to the end of the shaft, or be mounted directly on the shaft.

Drive by the first method does not differ from any other belt transmission, but the motor pulley will be small compared to the band wheel on the compressor, and so if no idler is used the distance between them must be long enough to permit proper belt contact on the motor pulley, and it is evident that the use of a very high speed motor is not advisable. Regard must also be given to the fact that the power demand of a compressor is pulsating, which makes it easy for the belt to start slipping. It follows that the belt should be liberally proportioned as to width so that it need not be run tight, and its surface should be kept in good tractive condition by cleanliness and, if necessary, the application in small quantities of the dressing recommended by the belt manufacturer.

Drive by ordinary open belt takes up a good deal of room, and a modification of it that is not expensive and that does save floor space can nearly always be used. It is known as the short belt drive, and is illustrated in figure 17 (t). The essential feature is the idler which carries the slack side of the belt down close to the tight side, greatly increasing the arc of contact on the motor pulley and so allowing more power to be transmitted without putting a destructive initial tension on the belt. A thin, flexible belt should be used, and it should be wide enough to do the work even if light and pliable. In many instances it will be possible to set the motor on an extension of the compressor foundation. The idler pulley is not intended to give the belt much initial tension, and should not be weighted with that end in view. Its only function is to give the belt a long wrap or arc of contact on the smaller pul-

(t) Worthington Pump & Machinery Corp., New York.
(u) Worthington Pump & Machinery Corp., New York.

ley and to hold it steady in that position. The short belt has this point of merit, that when a compressor station must be hastily assembled and put to work, as for a tunnel or other large contract, standard motors with pulleys and standard belted compressors may be picked up anywhere on the open market, while delivery on special slow-speed motors for direct mounting is sometimes quite slow. These standard items can probably also be disposed of quickly when the job is finished.

If motor and compressor are both to be purchased and the installation is to be permanent, the direct-connected unit is usually preferable. It is practically the only motor-driven type obtainable in capacities above 1,500 cubic feet per minute, since over this size the belt becomes too expensive and cumbersome. The direct-connected motor must run at the same speed as the compressor, which means a motor of slow speed and large diameter. If coupled to the end of the compressor shaft the motor must have its own shaft and bearings, and can be used only in connection with the same types of compressors as were listed for coupling to Diesel engines. The arrangement will require more floor space and a larger foundation than the more common design in which the revolving part of the motor is mounted directly on the compressor shaft between the main bearings if the machine is duplex and between the main frame and outboard bearing if not. The weight of the revolving part or rotor is nearly equivalent to the same weight of flywheel, though it is not usually sufficient for that purpose in itself, so that an additional flywheel must be supplied. The frames or bearings must be far enough apart so that the stationary frame of the motor may be slid to one side to give access to the rotor. A typical two-stage compressor driven in this way is illustrated in figure 18 (u). This shows a synchronous motor, and practically all those used for direct connection to compressors are of this class.

Electric power is now distributed almost entirely by alternating current. Direct current is found only in the down-town sections of a few of our large cities, and in industrial plants where there is some special reason for using it. Direct current motors of fair efficiency can be built to run at the slow speeds required for compressors, but there is so little demand for them that one, if ordered, would possibly have to be specially built, and so would be unduly expensive. If this is found to be the case and direct current must be used, due consideration should be given to the short belt drive from a standard medium-speed direct-current motor. Sometimes a slow-speed motor can be picked up in the used machinery market that will fit conditions near enough to be suitable for connection to the compressor by flexible coupling.

Alternating current motors of either the squirrel cage or wound rotor class are suitable for driving compressors by belts, but in the slow speeds necessary for direct connection they are commercially out of the question. They would be expensive in first cost for the power developed, but the worst feature is that at low speeds both efficiency and power factor are very poor, especially the latter. This means that the customer who is buying his power would be paying for current that he has not used, whereas the synchronous motor can be used to

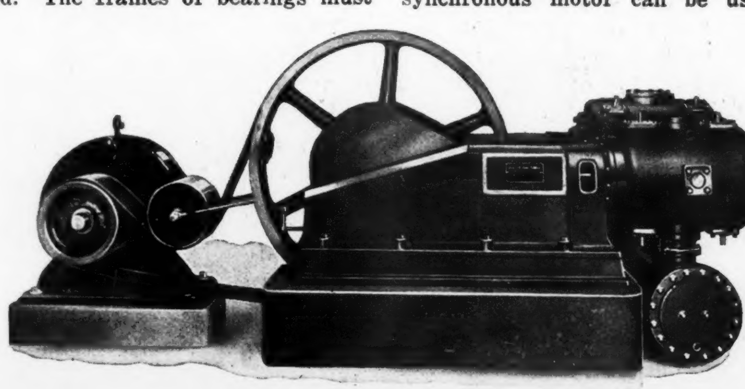


Figure 17

compensate for the power factor of other motors, and has a high efficiency even at low speeds.

The conventional synchronous motor has the field poles projecting outwardly from the rim of a spider which is mounted on the shaft and forms the revolving element of the machine. This has come about through a desire to have the power windings, which may be subject to a voltage of from 440 to 2,200 or more, stationary, and because the exciting current is small in volume, is usually at 110 volts, and can be easily and safely sent into the field through two collector rings.

There is no fundamental reason why this arrangement can not be departed from, and it has been done by one manufacturer in the design of a synchronous motor drive for the smaller compressors. In this design the power windings are on the face of a laminated ring rigidly mounted on the side of the compressor bearing. The shaft projects through this and carries a flywheel with an L-shaped rim, and the field poles are attached to the inner surface of the overhand and project inwardly toward the power windings. Exciting current is sent to the field through collector rings in the usual way. This is an inversion of the standard synchronous motor, but the elements of a revolving field and stationary power windings are maintained, and the new design is electrically equivalent to the old.

The weight of this revolving field is much more effective as a flywheel than if it were the inner member of the motor. If it is still not heavy enough it can be made so by adding more metal to the outside of the rim without interfering with the design of the motor in any other way. The exciter may be driven by belt on the outside of the field if necessary.

Direction of Rotation

It is well known that steam engines almost always run "over"—that is, the top of the flywheel turns away from the cylinder. A little thought will show that in this way the pressure of the cross-head is always downward on its guides, so that no transverse tensile or bending stress is exerted on the frame, other than that due to the direct force between piston and crank. Further consideration will bring out the fact that for

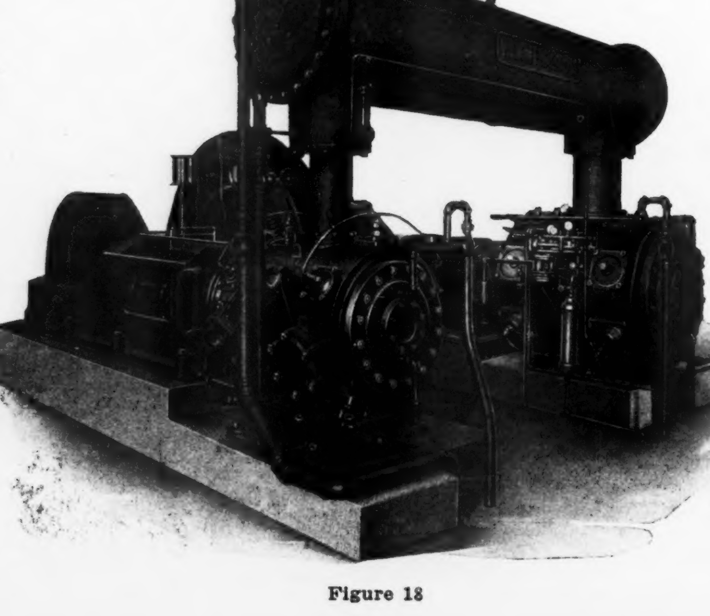


Figure 18

the cross-head of a belt or direct motor driven compressor to exert its pressure downward the machine must run "under," or what would at first seem to be backward. This is the customary way to run them, and the splash oiling systems are arranged with this in view. If it is absolutely imperative that such a machine be run forward the matter should be taken up with the builder.

The case is different with the self-contained steam or oil-engine driven compressor. Here much of the work is transmitted from the power to the air cylinder directly through the piston rod, and the rotating parts serve only to smooth out irregularities and cyclic variations. In these machines under certain conditions the pressure of the cross-head may be alternately upward and downward no matter what the direction of rotation, but it is customary to run such compressors forward.

Westeco Reversible Teeth

The new Westeco reversible teeth for dippers, clam shells and drag line buckets, according to the claim of the manufacturer, have the advantage of being easily changed and quickly reversed.

Their performance in actual operation has been most pleasing and the manufacturers report that at one installation they were used on a ¾-yard shovel working through heavy frost conditions during the winter and have handled, up to date, 100,000 yards of earth with only slight rounding of the points of the two middle teeth. The producer believes they will outlast another 100,000 yards.

Westeco teeth are made under the V. G. Honstain patent and are especially designed for heavy duty work such as moving frozen sand and gravel. Westeco is an alloy, controlled exclusively by the manufacturer and they claimed it to be considerably tougher and harder than manganese steel.

Tests on the job have demonstrated to the manufacturers that the design of their teeth is correct and adapted to all the needs of bucket and shovel users. One ore company reports that it has reduced the amount of blasting necessary by the installation of these teeth.

One of the features which is particularly notable is the ease with which they can be changed. It is claimed that teeth on a 1¾ yard bucket can be changed in from two and a half to five minutes and that the reversal of a tooth point is the matter of only few seconds. This avoids costly shut downs when teeth wear out and expensive installations.

Compressed Air Standards

A second edition of the Compressed Air Society's booklet "Trade Standards" has just been issued. This edition was the result of the enthusiastic reception of the first issue by all interested in pneumatic machinery. The new booklet contains all the good points of its predecessor and in addition has a quantity of valuable tables and a chapter of general information relating to commercial practices in the industry. Every page of the booklet bears evidence of extended research and study on the part of the engineers and executives associated with the society.

The first chapter deals with nomenclature and terminology and goes a long way toward clearing up some of the misunderstandings which may have developed in the minds of users due to different methods of describing the same thing on the part of manufacturers.

Proper compressor speeds and standard capacities and pressures are given ample treatment. In these sections the tabular matter is especially interesting. There are tables on atmospheric pressure and barometer readings at different altitudes, displacement in cubic feet per minute, transmission, theoretical horse power required and on the discharge of air through high pressure orifices.

The installation, care and lubrication of the compressor are discussed at length. The recommendations of the society for standards of practice in testing are also set forth. Although these were adopted in 1916, many of them are not generally known among the users of compressed air.

Gary Lime and Cement Co., Gary, Ind. Capital $25,000; deal in building materials. Directors: Harry I. Pierce, Samuel H. James, Marie Pierce and Bess James.

Consolidated Cement Corporation, Jefferson City, Mo. Capital $2,000. To buy, sell and deal in cement, clays, gravel and their by-products. D. C. Johns, L. C. Overstreet, C. V. Byers, Jr., incorporators.

Freight Car Loading

Loading of revenue freight for the week ending March 13, totaled 967,411 cars according to reports filed by the carriers with the car service division of the American Railway Association. This was an increase of 41,292 cars compared with the corresponding week last year and 50,644 cars over the corresponding week in 1924. Compared with the preceding week, the total for the week ended on March 13 was an increase of 2,730 cars, increases being reported in the total loading of all commodities except live stock, forest products and miscellaneous freight.

Miscellaneous loading for the week of March 13 totaled 346,053 cars a decrease of 1,286 cars under the week before but 1,623 cars above the same week in 1925. It also was an increase of 29,312 cars above the same week in 1924. Loading of grain and grain products amounted to 40,273 cars, an increase of 19 cars over the week before and 3,116 cars over the same week in 1925. It was, however, a decrease of 2,273 cars below the same week in 1924.

Coal loading totaled 188,834 cars, an increase of 6,391 cars over the week before and 38,282 cars above the same week in 1925. Compared with the same week in 1924, it also was an increase of 18,321 cars.

Loading of merchandise and less than carload lot freight amounted to 264,861 cars, an increase of 622 cars over the week before and 5,036 cars above the same week in 1925. Compared with the corresponding period in 1924, it also was an increase of 13,740 cars.

Compared with the preceding week this year all districts except the northwestern, central western, and southwestern showed increases in the total loading of all commodities. All dis tricts showed increases over the corresponding week in 1925 except the southwestern while all reported increases over the corresponding period in 1924 except the northwestern district.

A comparison by weeks follows:

	1926	1925	1924
January 2	741,239	467,098	706,292
January 9	907,119	934,170	871,023
January 16	936,655	934,022	894,851
January 23	921,734	924,291	891,481
January 30	925,263	897,368	929,623
February 6	914,904	929,130	906,017
February 13	917,144	903,935	935,589
February 20	931,743	925,886	845,699
February 27	912,658	864,096	944,514
March 6	964,681	932,054	929,381
March 13	967,411	915,119	916,767

Economy Pumps

A bulletin describing three models of double suction pumps is being sent out by the Economy Pumping Company. Two of the models, known as types "M" and "H" are conventional in that they follow the best established engineering practice for this type of machinery but the design of type "SM" involves some innovations since pumps for from 10 to 225 g.p.m. against heads of less than 100 feet, have heretofore been manufactured economically only in the vertically split type.

Types "M" and "H" are for capacities of from 150 to 6,000 g.p.m. against medium and high heads respectively. Economy pumps may be driven by electric motors, steam turbines, either geared or direct driven, gasoline engines, steam egnines, water turbines belt or chain drive. Belt driven pumps are arranged either with extended shaft, pulley and single outboard bearing or for larger powers, with flexible coupling and pulley mounted on stub shaft between two pedestal bearings.

Both "M" and "H" pumps are of the double suction, horizontal split case, single stage design, with suction and discharge in the lower part of the case. The construction permits the removal of the cover and working parts without disturbing the pipe connections. The casing is cast iron heavily flanged and ribbed and the impeller is cast in one piece of special bronze. The "M" pumps have broad flat wearing rings and the "H" have labyrinth type rings. The shaft of alloy steel is encased in renewable bronze sleeves which extend through the stuffing box.

The "SM" pumps are made without shaft sleeves or wearing rings in order to effect manufacturing economy. It has been considered advisable to make this economy since in the small sizes shafts and impellers can be replaced at practically the cost of sleeves and rings.

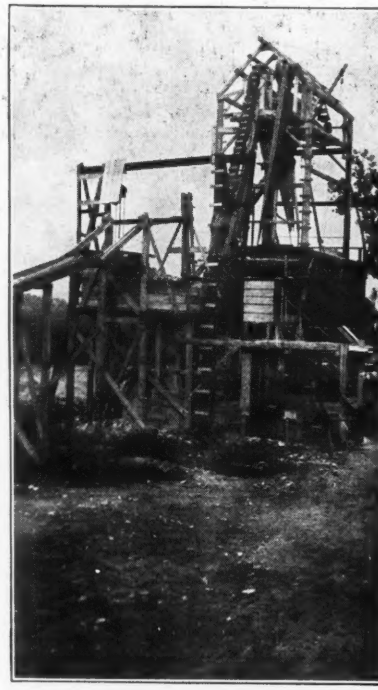
Harry A. Schmehl, Wilmington, Del. Capital $100,000. (Lime, plaster) Franklin L. Mettler, Wilmington, Del., incorporator.

The Rapp-Huckins Company are an old and well-established firm. During the past twenty-five years, they have handled marine and industrial engines. They maintain a show room, as well as a first-class service station.

Flood Proves Serious Handicap

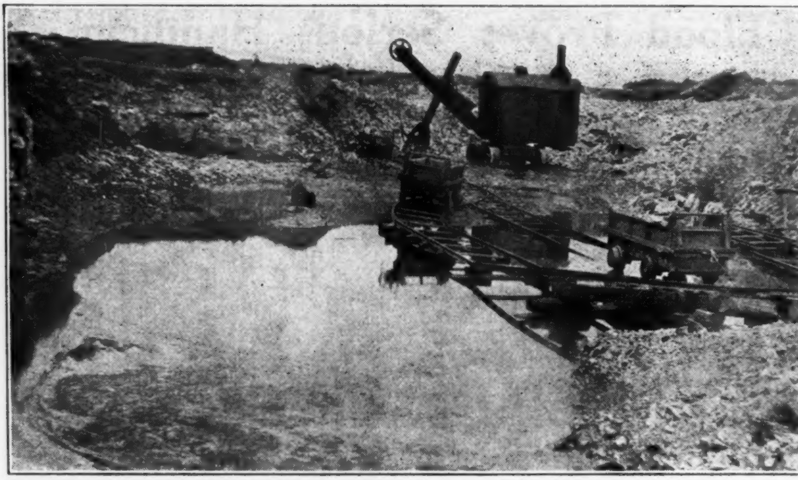
OVERCOMING the handicaps of quarry water and flooding streams, the Indiana Stone Products Company, Inc., is operating an economical crushed stone plant near Logansport, Indiana. The company, which has its headquarters at Indianapolis, obtained a contract from the state to supply crushed stone for highways and began paper operations at the Logansport site in April of 1924. Along the banks of the Wabash, Spring is an extremely wet affair and the heavy rains retarded considerably the removal of the overburden which varies in depth from two to six feet.

However the first blast was made in record time, considering the weather, and a number 4 Kennedy Van Saun crusher was installed. At first, quarrying was done entirely by hand, but a steam shovel was soon obtained which led to more balanced operation. Then came the trouble with water. A pump house had to be constructed and a pump set to work continuously to keep the quarry floor in working condition. Next, Rock Creek, which empties into the Wabash near by, and which runs a hundred feet south of the quarry, overflowed its banks attaining a stage of 18 inches more than can be recalled by "the oldest inhabitant." This flooded the quarry completely so that only a short piece of smoke stack on the steam shovel was visible. But W. C. Reinheimer, the plant superintendent, was not daunted by this bad luck, and when the stream subsided and the pump had made the place workable, he promptly recommenced operations.



Crushing and Screening Plant of Indiana Stone Products Company Located Near Logansport

View of Quarry Showing Pumping



Water Always a Factor at This Quarry

The plant has a capacity of 250 yards of crushed stone daily. Because of the size of the operation, no heavy investment in machinery has been made as yet. The blasted material is hauled from the quarry floor to the crushing plant by Easton 1⅛ yard end dump cars hauled up by a cable. Power for the plant is supplied by a 50 h.p. gasoline engine. The material is dumped in the boot pit of a bucket elevator and hoisted to the crusher. From there it is chuted to bins from which it is loaded onto trucks and hauled away.

The officers of the Indiana Stone Products Company are C. F. Kreis, president, and C. A. Bates, secretary-treasurer.

Universal Gypsum Co., Chicago, Ill. Capital increased from $24,000,000 to $34,000,000.

Concrete Specialty Co., Chicago, Ill. Capital $30,000. Manufacture and deal in building materials, articles of concrete, cement or similar products, radio apparatus, etc. Incorporators: Fred W. Karge, Fred H. Fricke and Willard F. Armstrong. Correspondent: Charles H. Miller, suite 1221, 105 W. Monroe St., Chicago.

Cars Carry Blasted Rock to Crusher

Distribution of Cement

The following figures show shipments from Portland cement mills distributed among the States to which cement was shipped during December, 1924 and 1925, and January, 1925 and 1926.

Portland cement shipped from mills into States, in December, 1924 and 1925, and January, 1925 and 1926, in barrels[a]

Shipped—	December 1924	December 1925	January 1925	January 1926
Alabama	121,826	108,906	85,410	129,291
Alaska	173	132	132	165
Arizona	37,459	61,646	34,370	38,869
Arkansas	41,627	43,281	41,376	46,708
California	738,110	938,721	988,883	931,238
Colorado	38,782	30,872	42,425	29,203
Connecticut	59,533	56,260	34,810	40,420
Delaware	7,884	13,680	5,786	8,815
District of Columbia	41,729	57,119	37,285	38,410
Florida	263,031	439,786	265,463	483,824
Georgia	121,333	69,046	93,062	80,129
Hawaii	1,164	20,735	417	10.757
Idaho	6,036	15,993	2,598	19,198
Illinois	328,101	407,808	463,388	323,947
Indiana	121,574	114,856	139,782	85,724
Iowa	31,141	41,325	53,044	28,439
Kansas	62,541	87,368	33,588	56,598
Kentucky	58,064	63,382	52,013	35,560
Louisiana	61,252	74,464	75,992	65,695
Maine	8,053	7,028	4,837	20,310
Maryland	87,137	85,377	47,635	79,497
Massachusetts	140,103	133,365	113,101	101,327
Michigan	178,516	302,889	190,905	222,061
Minnesota	59,101	62,943	59,395	66,063
Mississippi	33,644	34,740	29,867	44,140
Missouri	121,461	207,230	115,141	137,343
Montana	6,923	7,382	5,334	9,716
Nebraska	28,363	34,633	31,832	23,788
Nevada	2,621	4,015	2,492	2,508
New Hampshire	16,176	22,586	9,419	17,081
New Jersey	290,069	329,054	157,612	254,912
New Mexico	6,271	10,258	7,911	33,613
New York	737,623	889,639	400,896	571,447
North Carolina	126,363	152,699	79,817	81,764
North Dakota	132	2,474	1,380	3,338
Ohio	221,142	339,030	259,628	220,728
Oklahoma	118,645	148,354	58,872	101,087
Oregon	43,844	46,531	54,117	53,995
Pennsylvania	436,794	597,328	288,916	426,140
Porto Rico	......	......	......	......
Rhode Island	23,818	26,721	15,668	18,694
South Carolina	47,310	54,545	46,840	44,723
South Dakota	3,627	6,397	4,331	6,413
Tennessee	71,319	80,322	69,669	66,379
Texas	236,875	284,061	260,540	270,231
Utah	6,316	21,135	3,794	10,655
Vermont	4,557	4,066	3,129	2,218
Virginia	73,039	72,698	54,455	61,645
Washington	49,976	82,364	85,969	72,393
West Virginia	47,324	63,066	45,912	39,983
Wisconsin	55,172	77,100	113,396	60,400
Wyoming	9,518	7,968	3,492	5,797
Unspecified	7,203	8,140	15,964	17,162
	5,440,450	6,851,500	5,092,090	5,600,541
Foreign countries	65,550	65,500	69,910	71,459
Total shipped from cement plants	5,506,000	†6,917,000	5,162,000	5,672,000

*Includes estimated distribution of shipments from three plants each month.
†Revised.

Estimated clinker (unground cement) at the mills at end of each month, 1925 and 1926, in barrels.

Month	1925	1926	Month	1925	1926
July	6,961,000	....	January	7,017,000	*9,074,000
August	5,640,000	....	February	8,497,000	10,928,000
September	4,561,000	....	March	9,962,000	....
October	4,086,000	....	April	9,731,000	....
November	5,013,000	....	May	9,053,000	....
December	*6,469,000	....	June	7,937,000	....

*Revised.

Miami Power Scraper Improvements

Changes and improvements incorporated in the new model Miami one-man power scraper have greatly increased its efficiency. Straight roller bearings are used on the wheels, a hardened and polished sleeve being pressed into the hub which can be replaced easily after long use. Hardened steel washers are driven into the ends of the hubs inclosing the sleeve and roller bearings in the hubs of the wheels and making them dirt proof. The frame is six inch channel steel, hot riveted throughout.

The scoop pan is 42x37x17 inches center level measurements and holds 15⅓ cubic feet level. By rounding the load ten inches it has a capacity of 20 cubic feet. A full rounded load can be taken easily by this scraper. The pan is $\frac{3}{16}$ inch high carbon plate and has a high carbon steel blade or cutting edge, is riveted to the lower front edge.

Stop castings are mounted on the track rails so that the scoop pan may be brought to its full dumping position, or within five inches of the vertical center, before the track rollers are fully engaged in these castings. Full dumping position is reached without engaging the two sheave wheels on the rear upright support or the sheave wheel on the scoop pan, thus leaving slack in the cable and making it impossible to fray it in full dumping position.

The fulcrum arm slides on the guide rod raising the rear end of the pan simultaneously with the front until it is nine inches from the ground. The rear of the pan is then stopped, the front raising to any position desired for carrying the load. None of the dirt is lost due to the elevated position. A spring is mounted on the guide rod to relieve the cable further of any strain or stress.

Power is derived from a Fordson tractor and a steel casting hitch provides a quick connection of the scraper and remains permanently on the tractor to be used for plowing or any other purpose.

The sturdy Miami power winch is bolted to the rear housing and axle of the tractor. It is not necessary to drill holes to attach the winch. The large SAE bronze gear, the hardened worm and two of the three Timken bearings are completely inclosed in the gear case and run in a bath of heavy cylinder oil. The front Timken bearing and ball thrust bearing are lubricated by grease cups. This winch also operates the Miami trench back filler.

The friction wheel is bolted to the power take off on the tractor in place of the ordinary belt pulley. The friction wheel operates at all times except when the clutch of the tractor is disengaged. The control lever is placed at the driver's right hand and is easily operated. When the lever is pulled backward it releases a cone clutch which permits the scoop pan to lower to any position. When the lever is thrown forward it engages the friction clutch and raises the pan.

Improved Miami Power Scraper On the Job

Atlas Belt Conveyors

It is stated by the manufacturers of Atlas portable belt conveyors, that they try out no novel features of design on their customers. The company adheres to what it has found the most practical and most efficient design and has developed a machine, which it insists, will be dependable under the most severe service. The Atlas conveyors, the manufacturers point out, have large capacity for the amount of power required and the cost of upkeep is small due to the steel construction throughout and the simplicity of design.

All Atlas conveyors are built up in multiples of three feet with 7½ foot head and foot sections. This permits the changing of the length of the conveyor on the job at any time and with little expense. The machines can be furnished in any length from 15 to 100 feet and with either 18 or 24 inch belt. Stationary conveyors can be furnished up to 300 feet in length. The conveyors are equipped with either an electric motor or a gasoline engine for power or can be supplied without the power unit.

The frame is built of $1\frac{3}{4} \times \frac{3}{16}$ steel angles with $1\frac{1}{2} \times \frac{1}{2}$ steel channels. The frame is hot riveted throughout under hydraulic pressure. The loading hopper is of a low type design and is fitted with belt flashings which keep the material from falling onto the return belt. The head and tail pulleys are one piece, heavy iron pipe construction, machine crowned, with heavy cast iron end.

The carrier rolls are of the three roller troughing type, and are of boiler tube construction with cast iron ends running on hollow pipe journals. These give the belt a gradual dish forcing the material to the center of the belt. The flat return rollers are of the same type only in one piece. The belt is four ply with a one-eighth inch rubber cover on the carrying side.

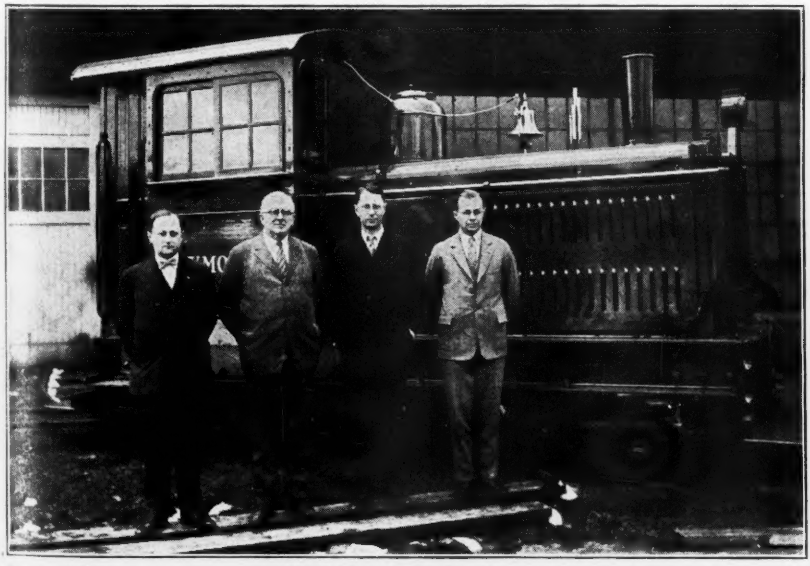
Plymouth Appoints New Sales Manager

Lawrence E. Buzard has been appointed General Sales Manager of The Fate-Root-Heath Company, Manufacturers of Plymouth Gasoline Locomotives, Plymouth, Ohio, succeeding H. R. Sykes who recently resigned.

Mr. Buzard, who was formerly Assistant Sales Manager, has been with the company a number of years and is thoroughly conversant with industrial haulage problems. He will have direct charge of locomotive sales and thirty-four district sales representatives.

Federal Gravel Co., 118 So. Jefferson Ave., Saginaw, Mich. Capital $200,000.

Name and Address of Manufacturers of Equipment Mentioned May Be Obtained from Publishers



Left to right: J. A. Root, president Fate-Root-Heath Co.; C. E. Heath, vice-president and general manager; P. H. Root, treasurer; L. E. Buzard, general sales manager.

New Bucyrus Shovel

A 3-yard revolving shovel for general use was announced by the Bucyrus Company, March 15th. This shovel is built particularly for the contractor and the general user of excavating machinery. It represents a departure in that it is built along lines never before used in shovels for general utility.

In design it follows the basic plan developed by the Bucyrus Company in building the 120-B a 4-yard mine and quarry full revolving shovel announced last year. In principle it is a machine that offers to the contractor and engineer engaged in excavation a machine that combines the advantages of a small revolving shovel with those offered by the railroad-type shovel, but has a working range considerably greater than either.

In brief the machine has the speed of action, big dipper capacity, ruggedness and power of the railroad-type shovel with the mobility, the full revolving swing and the maneuvering ability of the small revolving shovel. The shovel is remarkably close coupled, the boom length being only 29 feet 6 inches and the rear end radius 16 feet.

Throughout the clearances have been held within close units so that the shovel is capable of working in close quarters and is suitable for any sort of digging.

Marion Mechanical Stokers

The Marion line of stokers includes, the full mechanical, semi-mechanical and hand stokers. The most recent addition to the line is the heavy duty, type "K", mechanical. The manufacturers say it is equally adapted to natural or forced draft; moderate or high ratings.

Coal is dropped to a hopper either by shovel or over head conveyor and is slowly fed upon the arch jams by the pushers. Here it is exposed to the radiant heat of the furnace and the light volatile matter is intermixed with preheated air and consumed. Before the coal reaches the fuel bed complete ignition has taken place. At this point more auxiliary air is supplied at the rear which causes the fuel to assume an active state of combustion. The stoking bars gradually advance the burning mass in accordance with the steam demands of the boiler. As the fuel moves rearward the quantity decreases until practically nothing remains but ash and clinkers. These are mechanically deposited on the dump grate.

With the Marion a breakdown need not interrupt boiler service. Should a mishap occur in the hopper feeding, a lever is inserted in a bracket and the furnace is fed by hand. Another lever will operate the stoking bars should trouble occur there

Name and Address of Manufacturers of Equipment Mentioned May Be Obtained from Publishers

New Bucyrus 100-B Shovel

Improvements in Heil Hoist

Important changes in the design of the Heil hoist have just been announced. These are of a decided importance to the dump truck operator because they make possible higher dumping angles, reduce weight and do away with all oil troubles. The application of power is direct. The hoist swings on its saddles.

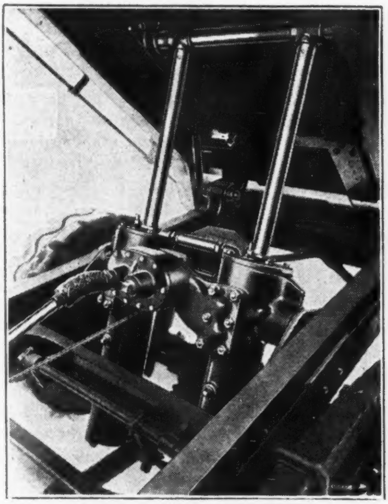
The gear pump in the manifold develops the pressure and forces the oil down the oilways on the front of the cylinders and under the piston head. This pressure raises the load. As the piston rods move out of the cylinders a supply of oil from the oil reservoir is required to take their place. This oil reservoir is now cast integrally with the hoist cylinder replacing the sheet metal tank and connections. This construction prevents all possibility of oil tank leaks.

The elimination of the sheet metal tank gives the new models a more finished appearance. The removal of the tank permits the servicing of any part of the hoist without the necessity of removing any other part.

The head of oil in the reservoir is now below the piston rod gland nuts instead of above preventing all possible chance of oil leaks around the piston rod. This together with the elimination of the oil tank will keep the hoist clean and free from oil accumulations. There is positive equalization of oil between cylinder reservoirs through an equalizer tube, eliminating the possibility of drawing air into the cylinders.

The oil is now drawn into the pump through the opening in the rear of the cylinder, then through an oil passage around the inner side of the cylinder. Because the oil opening is at the rear of the cylinders the tilting of the hoist in raising assures a positive flow of oil to the pump at all times, thus eliminating the churning of oil. The distance between the piston head and the cylinder head when the hoist is in extreme raised position has more than doubled giving a better support and greater rigidity to the piston rod.

The oil capacity of the new style number 4S-26 hoist is 16 quarts whereas the oil capacity of the old number 4S hoist has 20 quarts. All other models have been reduced in proportion. The weight of the hoists filled with oil has been reduced from 20 to 40 pounds, an important amount for haulers in certain states.



Improved Heil Hoist

The piston stroke has been increased 2 inches on model 4S-26 as well as on other models. This increases the dumping angle approximately five degrees as well as increases ground clearance. A cylinder head strut between cylinder heads can be used in place of the link bar making the hoist easy to mount. The hoist frame still remains 36 inches long and gives 6 inches greater adjustability for body installations. A combination fill and air vent on the cylinder heads prevents the body from back tipping.

The simplicity of the Heil Hoist meets with great favor among haulers of all kinds. The twin cylinder feature reduces the average working pressure but makes available a tremendous lifting power for an emergency. The pump can develop 1,000 pounds per square inch of piston head area.

Interstate Sand & Gravel Co., Wilmington, Del., Capital $150,000. (To own and operate sand quarries, etc.)

The White Sand and Gravel Co., Elkhart, Ind. Capital $25,000. Sand and gravel construction work; directors: LeRoy White, Adelaide White, Elliott Crull.

Lammot du Pont Elected President

Directors of the E. I. du Pont de Nemours and Company on March 15 elected Lammot du Pont as president of the firm to succeed Irenee du Pont, who desired to be released from the duties so that he might devote more of his time to personal affairs.

The retiring president was made vice-chairman of the board of directors and chairman of the finance committee. He retired from the executive committee and the new president was made its chairman.

Lammot du Pont is the eighth member of the du Pont family to head the company since the business was founded in 1802 and the third brother to hold the presidency in succession. Pierre S. du Pont, the first of this trio, was at the helm from 1915 to 1919, during the period of the World War, when the bulk of munitions production for the allies fell to the company's lot. He was succeeded by Irenee, who, as senior vice-president, had been importantly identified with the war period work as was Lammot, also a vice-president and member of the executive committee.

Lammot du Pont, the son of Lammot du Pont, who was the first to establish the dynamite business in this country on a permanent commercial basis, was born in 1880. Shortly after graduating from the Massachusetts Institute of Technology in 1902 he entered the employ of the du Pont company and has spent his entire business life in its service. When the company was reorganized in 1915, he was elected a director and member of the Executive Committee and the next year was made a vice-president. For several years he was in charge of the Miscellaneous Manufacturing Department, which included the company's expanding interests in dyestuffs, pyralin, paint and chemicals, in the development of all of which he had an active part.

In more recent years, as chairman and vice-chairman of the Executive Committee and as a member of the Finance Committee, he has been engaged with the administrative affairs of the company.

Mr. du Pont has been importantly identified, as director or officer, with the affairs of the parent company's subsidiaries and affiliated companies.

Portable Acetylene Generator

As a safe-guard against tieups due to broken machinery many pits and quarries have been equipped with welding and cutting outfits and portable acetylene generators. With a torch on hand that will either cut or weld by a mere interchange of the tips, the plant manager is assured of a means of combating any emergency requiring cutting or welding.

However, in various plants remote from a convenient source of supply of gas, a portable acetylene generator is employed. Even in quarries where there is a good bit of welding to be performed, it is found advantageous and economical to use an acetylene generator. This obviates the delays in obtaining cylinder gas, assuring a supply of acetylene gas when and where required.

The Alexander Milburn Company, manufacturers of oxy-acetylene welding and cutting equipment and portable carbide lights have recently placed on the market a portable acetylene welding generator designed to obviate the use of high pressure cylinders which they believe will be especially handy in quarries.

The generator is of 30 pounds carbide capacity, or the equivalent of 150 feet of cylinder gas. It is simple to operate, having few parts, and operates automatically without any clock or motor. The steel body is welded throughout, insuring a gas-tight generator.

The interference-rod on the new generator insures absolute safety at all times and renders the generator fool-proof. The interference-rod must be moved before charging the generator with carbide. This automatically releases all pressure within generator, at the same time removing interference from carbide filling plug, water filling valve and sludge valve.

The generator is two feet in diameter at the bottom and fourteen inches in diameter at the top, standing five feet high. It weighs 200 pounds when empty and has a shipping weight of approximately 425 pounds. The hopper and head are in one unit. The entire feed control is a self-contained unit attached to side of hopper. The generator can be quickly and easily recharged with carbide and has an oversize sludge outlet, permitting quick removal of the spent carbide. The generator uses ¼x½ inch carbide,